PRELIMINARY FAIRBANKS BEE POLLINATOR PROTECTION PLAN

By

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ABSTRACT

Global declines in pollinator species have been documented in several studies across the United States, Canada, and Europe. Honeybees, bumble bees and Monarch butterflies have been hit particularly hard in the US. This Preliminary Fairbanks Bee Pollinator Protection Plan recommends ways to increase public awareness of the problems facing bees and other pollinators, methods to increase and protect pollinator habitat and steps to take to reduce the use of pesticides. The plan also includes a list of native and non-native plants that grow well in the Fairbanks area and that are attractive to insect pollinators. Planting these species can greatly increase the local habitat for pollinators.

In developing the plan, I evaluated 12 pollinator plans from other areas, learned about local pollinators and their habitat requirements, and surveyed local beekeepers. To create the goals, objectives and actions included in this plan, I combined ideas from each of these three sources plus ideas of my own.

The plan is not intended to be implemented by any one individual or agency. Instead, the plan can be used by anyone interested in improving pollinator habitat. If you have a backyard, access to a community garden, or just a few pots or a windowsill, you can create pollinator habitat. In addition to individuals, there are many businesses, government agencies, non-profits and other organizations that may be interested in taking steps listed in the plan to benefit bees and other pollinators.

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Bombus occidentalis pollinates a wild rose in Fairbanks, Alaska. Credit: Rehanon Pampell

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Table of Contents

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INTRODUCTION

This draft plan was prepared as part of my graduate program in Natural Resource Management. My hope is that this "preliminary" plan will serve as a starting point to show the types of actions local people and agencies can take to protect pollinators in the Fairbanks area. While the plan is focused primarily on native bees, the steps called for will also benefit honeybees and other insect pollinators. The plan recommends ways to increase public awareness of the problems with pollinators, methods to increase and protect pollinator habitat and steps to take to reduce the use of pesticides.

The plan is not intended to be implemented by any one individual or agency. Instead, the plan can be used by anyone interested in improving pollinator habitat. If you have a backyard, access to a community garden, or just a few pots or a windowsill, you can create pollinator habitat. In addition to individuals, there are many organizations that may be interested, including the City of Fairbanks, the Fairbanks North Star Borough Department of Parks and Recreation, the National Resource Conservation Service (NRCS), the Fairbanks Soil and Water Conservation District, the Cooperative Extension Service, the Georgeson Botanical Garden, the University of Alaska, the Fairbanks Garden Club, tribal organizations, nonprofits and many others. It will not be necessary for any one agency to adopt the plan officially, because many partners will be needed to implement it and the decision to take many of these steps can be made at the operational level (such as departments in charge of landscaping).

Pollinators are animals that visit flowering plants and transfer pollen in the process, thus enabling plants to reproduce. Common pollinators include bees, flies, butterflies and other insects, hummingbirds and bats. The most widely known pollinator is the domesticated honeybee, but there are over 20,000 species of bees in the world and 4,000 species just in the US (Potts et al, 2016; Danforth et al., 2006; Michener, 2000).

Over the last few decades, the populations of many pollinators have been declining, putting ecosystems and much of our food supply at risk (Potts et al., 2016). In response, the United States Environmental Protection Agency (EPA) in 2008 recommended that every state develop a pollinator protection plan (Environmental Protection Agency, 2008). In June 2014, President Obama issued a Presidential Memorandum stating the importance of pollinators and the need to protect them (Obama, 2014). As a result of these actions, several states developed pollinator protection plans that helped formulate state laws and regulations regarding pesticide use and restrictions (Pollinator Health Task Force, 2016). Several cities across the lower 48, Canada, and Europe have also created pollinator protection plans to deal with the crisis.

Alaska is home to many insect pollinators including bumble bees, non-native pollinators (European honeybees), wasps, flies, butterflies and several more. According to the United States Department of Agriculture Natural Resource Conservation Service (NRCS, n.d.), there are 47 species of bumble bees in North America, 23 of which are found in Alaska. NRCS estimates that more than 9 million European honeybees are imported into Alaska each year for honey production. These bees also play a significant role in pollinating both wild and domestic plants.

Pollinators are the cornerstone of the food chain; their influence reaches far beyond flower gardens. According to Wojcik (2016, p.1), "1,000 out of 1,200 common crops are pollinator-dependent." This means that over 30% of the food we eat is dependent on pollinators. Alaskan insects are well adapted to the extreme climate, but they are not immune to the effects of habitat loss, pesticides, diseases/parasites, climate change and urbanization. Pollinator research is limited for the state of Alaska, and very few studies have explored pollinator populations in the interior.

HOW THE PLAN WAS DEVELOPED

In developing the plan, I evaluated pollinator plans from other areas, learned about local pollinators and their habitat requirements, and surveyed local beekeepers. To create the goals, objectives and actions included in this plan, I combined ideas from each of these three sources plus ideas of my own.

My first step was to review 12 city, county and state pollinator plans to see what types of actions the plans called for, what public engagement methods they used, and how their plans were structured. More information on the plan reviews, the criteria and the results can be found in Appendix A.

Next, I reviewed information on insect pollinators found in the Fairbanks area. The purpose of this review was to familiarize myself with local pollinators, help develop my survey of local beekeepers, and learn about the vulnerabilities of wild and managed pollinators in Alaska. I used the information to create a pollinator science section, shown in Appendix B, which includes general pollinator information, common species of pollinators found in the Fairbanks area, their foraging habits, habitat requirements, and life cycles.

I also conducted a survey of local beekeepers. The purpose was to find out what beekeepers have experienced, what actions they consider necessary to promote pollinators in Fairbanks, and what the primary threats are to local honeybees so that we can create a plan to address those needs. More on the methods and survey results can be found in Appendix C.

Ideally, many more stakeholders would be involved, either through meetings or surveys, but I did not have enough time or funding to complete that. However, I believe this preliminary document would benefit from additional public input through both surveys and public meetings.

POLLINATORS NEED OUR HELP

According to a global assessment on pollinators by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), global declines in pollinator species richness and abundance have been documented in several studies comparing historic records against current observations around the world (IPBES, 2017). These studies raise serious concerns about the effect that pollinator decline will have on natural ecosystems and our food security (IPBES, 2017; Potts et al., 2010). First, I discuss the status of wild and managed insect pollinators and then discuss the possible causes of the declines.

Wild Insect Pollinators

Wild insect pollinator data is largely unavailable at the global scale, but declines in the abundance, occurrence and diversity of wild bees and butterflies is well-documented in parts of northwest Europe and the US (IPBES, 2017; Potts et al., 2010). The first bee species to be placed on the US Endangered Species list occurred in 2016, when seven species of *Hylaeus* yellow-faced bees from Hawaii were listed as endangered (Wang, 2016).

Eastern bumble bee (Bombus impatiens). Photo by Ryan Hodnett, Wikimedia Commons.

Bumble bee populations have experienced rapid declines within the last few decades (Jacobson et al., 2018). They are native species that evolved with the plants they pollinate, but they also pollinate many crops like tomatoes and cranberries. In 2017, a species of bumble bee (*Bombus affinis*) was the first bee species in the contiguous US to be listed by the USFWS as endangered (USFWS, 2020). *B. affinis* once ranged from Georgia to Maine to Minnesota. The population plunged nearly 90% in distribution and abundance between the late 1990s and 2016 (Gorman, 2017). Another species, *B. franklini*, that occurred in a small area around the California/Oregon border, has not been seen in the wild since 2006, when a single individual was observed. In 2019, the USFWS proposed to list this species as an endangered species. But the proposal indicated that it is probably be too late, "based on the lack of observations [since 2006] it is possible that the species is extinct" (USFWS 2019).

In response to global concerns regarding the status of bumble bees, the International Union for Conservation of Nature (IUCN) formed a Bumblebee Specialist Group in 2012 to assess the 265 species of *Bombus* worldwide. According to their latest report, of the 47 species in North America, 12 (26%) face serious threats. They list five North American species of *Bombus* (including *affinis, bohemicus, intrudens, franklini*, and *suckleyi*) as critically endangered, two species (*crotchii* and *fraternus*) as endangered and another five species (*caliginosus, fervidus, occidentalis. Pensylvanicus*, and *terricola*) as vulnerable (IUCN Bumblebee Specialist Group, 2020). In Europe, they listed 13 (21%) of the 63 species as endangered, including one critically endangered.

Did you know?

Native Alaskan bumble bees have been observed foraging during snowfall, at night, and in temperatures as cold as -3.6°C (Heinrich, 1979).

Climate change may be contributing to this decline. A recent study compared the locations where 66 species of bumble bees had been found between 1901 and 1974 with the places where they were found between 2000 and 2014 (Soroye, 2020). They found the number of areas populated by bumble bees had fallen by 46% in North America and 17% in Europe. These same areas also experienced higher temperatures, heat waves and other extreme weather patterns. Bumble bees have large bodies and thick coats of hair that make them well-adapted to colder climates, but as discussed below, this also makes them particularly vulnerable to warming temperatures (Rasmont, 2013; Soroye, 2020).

Many species of butterflies are also declining. According to the IUCN the European Red List of Butterflies, there is 1 regionally extinct, 3 critically endangered, 12 endangered, and 12 vulnerable butterfly species in Europe (Van Swaay et al. 2010). In North America, one of the most studied butterfly species is the monarch (*Danaus plexippus*). There are two migratory populations of monarch butterflies: the western population primarily overwinters in coastal California and breeds west of the Rocky Mountains, and the larger eastern populations overwinter in the Sierra Madre Mountains of Mexico and breed east of the Rocky Mountains stretching to the northern United States and southern Canada (Wilcox et al., 2019; Crone et al., 2019). Over the past half century, eastern populations of monarch butterflies have declined by 80%, and the western populations have declined by 95% (Crone et al., 2019). To put this into perspective, in the 1980's the western population was estimated at 4.5 million, but in 2019 populations have fallen further to 29,000, which is less than 1% of the historic population and below the projected threshold for collapse of the western monarch migration (Pelton, 2020). Possible causes of the decline include the availability of suitable environmental conditions, deforestation, contaminants, breeding habitat loss, predation, parasites, pathogens, and drought (Wilcox et al., 2019; Forister et al. 2018; Forister et al. 2009).

Monarch butterfly (Danaus plexippus) Photo by Axel Tschentscher, Wikimedia Commons

"The decline of monarch butterflies has been observed like a 'silent spring,' with biologists and casual observers alike noticing the missing butterflies from so many of our recent summers." —Anurag Agrawal (2019, p.8093)

With respect to other wild insect pollinators, an IUCN Red List assessment is only available for Europe. The study assessed 1,942 wild bee species and classified 7 species as critically endangered, 46 as endangered and 24 as vulnerable (Nieto et al., 2014). Charismatic species tend to get the most attention, but more research is needed worldwide on the status of all wild insect pollinators.

Managed Insect Pollinators

Managed pollinators include the well-known honeybee (*Apis mellifera)* as well as a growing variety of bee species such as bumble bees, stingless bees, and solitary bees that are used for commercial pollination services for crops (IPBES, 2017). There were major concerns about honeybees in 2006-2007 when many colonies died. Referred to as Colony Collapse Disorder (CCD), it is attributed to the interaction of several stressors, including the parasitic *Varroa* mite, poor nutrition from monocultures and pesticides (Goulson, 2015; Newmann & Carreck, 2010). New treatments for V. *destructor* reduced its impact on honeybees, but many beekeepers continue to report higher colony mortality than the usual rate of 10% to 30% per

year in the Northern Hemisphere (IPBES, 2017). As discussed below, pesticides (particularly neonicitinoids) are also a major concern for honeybees.

Other species of managed pollinators are slowly being introduced as an alternative to the honeybee for two reasons: 1) to reduce the dependency on a single species for pollination services, and 2) because some pollinator species are more efficient at pollinating crops than others (IPBES, 2017). However, there are concerns about using bumble bees, stingless bees, and solitary bees as managed species of pollinators due to the threat that pathogens could spill over into wild populations and that new species of managed bees will compete with native bee populations (IPBES, 2017).

While this plan focuses on insect pollinators, it is important to point out that pollination services are provided by both vertebrates and invertebrates; thus, it is important to note the broad decline in vertebrate pollinator populations. The data for vertebrate pollinators is more extensive than insect pollinators, which allows the IUCN to make global assessments on the status of many vertebrate pollinator populations. The IUCN estimates that 16.5% of vertebrate pollinators (mostly birds and bats) are threatened with extinction and the number increases to 30% for island species (Potts, et al., 2016).

Primary Causes of the Decline

Linking pollinator declines with specific or multiple drivers is not often possible due to the lack of data on the status of pollinators (Potts, et al., 2016). Nonetheless, many studies around the world that point to several drivers that threaten pollinator abundance, diversity, and health of wild and managed pollinators (Potts, et al., 2016). These include habitat loss, pesticides, climate change, and diseases and pests. The growing evidence of pollinator loss in Europe has resulted in several government initiatives by local, county and national governments to reduce the loss (IPBES, 2017; Kosior et al., 2007).

Habitat Loss

Pollinator species richness is positively related to the scale and yield of local plants, and can be negatively affected by agricultural intensification, habitat fragmentation, and habitat loss (IPBES, 2017; Bartomeus et al., 2014). Quantitative synthesis of local-scale studies suggests that agricultural intensification and habitat fragmentation disperse pollinators from traditional forging areas and is likely to cause pollinator abundance and richness to decline in many parts of the world (IPBES, 2017; Vanbergen et al., 2013). Pollinator losses are biased towards species with particular traits or "specialized pollinators" that depend on a narrow variety of plants for pollination services, nourishment, and habitat (Potts et al. 2010; Vanbergen et al., 2013).

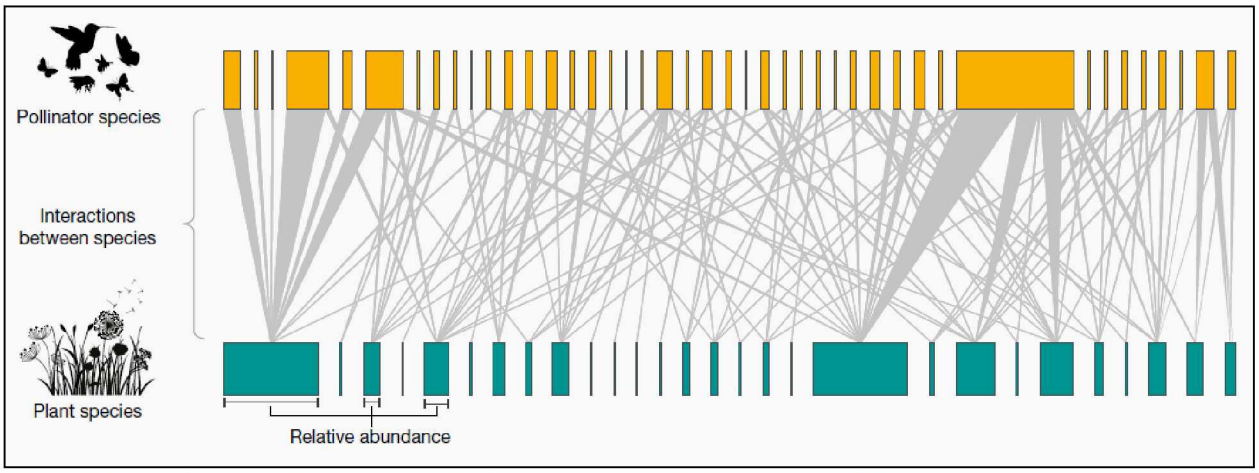


Figure 1. Example of a pollinator network. The upper orange blocks represent different pollinator species, while the lower green blocks represent plant species, the width of each block represents the relative species abundance of

either pollinators or plants, and the lines connecting the blocks represent plant-insect interactions (IPBES, 2017, p.174).

Pesticides

Pesticides in an apple orchid- H.J. Larsen, Bugwood.org

Insecticides and herbicides often accompany urbanization and land use intensification. Pesticides are chemical agents designed to control unwanted organisms. Pesticides are used in agriculture, cities, roadsides, homes, and on private land. An often-overlooked fact is that pesticides can affect non-targeted pollinators. Insecticides, herbicides and fungicides are types of pesticides that are designed to control insects, plants, and fungi, respectively. Whether organic or synthetic, all insecticides, some herbicides, and several fungicides can cause high mortality rates among pollinators, reducing pollinator diversity and abundance (Schell et al., 2017; Potts et al., 2010). Herbicides can kill food sources such as dandelions that is an important source of nourishment in early spring for an assortment of pollinators. Neonicotinoid insecticides are highly toxic to many invertebrates, especially insects, and a recent study indicates that exposure to these during brood or early-adult development reduces brain growth and could impair learning and navigation in bees (Smith et al. 2020).

Climate Change

The biggest climate change concern for native pollinators is phenological shifts. In a recent study conducted in Fairbanks, Alaska, researchers documented earlier springs, later falls and a 21% increase in growing degree days, which influences the timing of flowering for the species our native pollinators depend on (Mulder & Spellman, 2019). While research in Interior Alaska has not yet been conducted on the potential for phenological mismatches, there is potential, particularly for specialized pollinators, for population declines due to differing and shifting timing of cues for pollinator emergence and flowering. Another effect of climate change is the observation of tree lines which are slowly progressing upslope into mountainous ranges and tundra. This can change habitats historically utilized by pollinators for nesting, overwintering, and foraging (Gehrig-Fasel et al., 2007). The pollinators that would suffer most from this change would be bumble bees, given that they thrive in cool and mountainous areas (Forister et al., 2010; Kerr et al., 2015).

A European study hypothesized that increasingly frequent annual heat waves may cause "Bumble Bee Scarcity Syndrome," which could result in a temporary local extinction of bumble bees (Rasmont et al., 2013). The frequency of heat waves is expected to increase dramatically in the future, which could endanger several bumble bee species (Meehl et al., 2004; Rasmont et al., 2013; Soroye et al., 2020). The changing climate is also causing pollinator species to move toward the poles (Kerr et al., 2015). This shift in biogeographic ranges of bumble bees and other pollinators may require us to take steps to protect both the species that are moving and those that, for some reason, cannot relocate (Rasmont et al., 2016).

Pests and Pathogens

Bees and other pollinators naturally suffer from pests and pathogens. Pests and pathogens can come from a variety of places both native and non-native spread through transportations and other means. In the case of bumble bees, international trade and management has led to "pathogen spillover" where native bumble bee species become infected with disease causing parasites which can lead to population decline (PBES, 2017). A large-scale study across the United States of 8 bombus species quantified major population declines, those species demonstrating the highest amount of loss found significantly higher prevalence of

Nosema in declining *B. occidentalis* (37%) and *B. pensylvanicus* (15.2%) than in the stable species; however, more research is needed to create a direct link to population decline and Nosema (Cameron et al., 2010). In a two-year study on bumble bees in Fairbanks, 2.5% of the specimens were found to be infected by Nosema spp. (Pampell et al, 2015). Pollinator declines in wild bees and managed bees are clearly due to multiple interacting factors (Goulson et al., 2015). While pollinator plans cannot do much about climate change or diseases and pests, they can address two of the key problems discussed here: habitat loss and pesticides.

VISION, GOALS, AND OBJECTIVES

Fairbanks has great potential to protect pollinators from the adverse impacts that they have experienced in other more urban or fragmented landscapes. With our land, biological and community assets in mind, this plan aims to set forth a vision and concrete actions that we could strategically undertake to conserve and protect our pollinator resources.

Vision for a Pollinator-Friendly Fairbanks:

Fairbanks is home to a diverse and growing population of pollinators that thrive in the area due to the work of individuals, community groups, local government, public agencies and other stakeholders.

GOALS	*Objectives*
1. Expand education outreach and awareness	A. Establish a nonprofit organization dedicated to pollinators B. Expand educational programs for Grades K-12 C. Celebrate Alaska's Pollinator Week D. Become the first city in Alaska to become a designated Bee City
2. Develop and enhance pollinator-friendly habitat in Fairbanks	A. Create pollinator gardens on both private and public land B. Establish a Pollinator Highway in downtown Fairbanks C. Leave areas of natural habitat
3. Minimize the use of pesticides harmful to pollinators	A. Increase awareness of alternatives to insecticides B. Increase awareness of alternatives to herbicides C. Incentivize pollinator-friendly businesses D. Minimize the risk of pesticide drift and contamination

GOAL 1: Expand education, outreach, and awareness

Local beekeepers were asked, "What could be done to reduce potential harm from chemical control of mosquitoes and other pests on other lands in the Fairbanks area?" In response, 87% of them chose "Community education on the dangers of pesticides" as the most desirable action to take. In the open-ended questions, 7 of the 30 survey respondents expressed their desire for education and awareness in protecting pollinators and honeybees. In addition, in my review of 12 pollinator protection plans, all of them included education and outreach as a priority for protecting pollinators. Education and awareness go hand-in-hand and are essential tools we can use to help pollinator populations.

Education about native pollinators. Remember that native pollinators and non-native honeybees may be at odds with one another. – Survey Respondent

Create TV commercials educating people on the difference between bees and wasps, importance of bee health and how the local community can help. – Survey Respondent

Objective A – Establish a nonprofit organization dedicated to pollinators

One of the first steps in raising awareness is to start a small nonprofit organization, such as a "Friends of Fairbanks Pollinators," dedicated to raising awareness about the problems pollinators face and to improving the health of pollinators in the Fairbanks area. The organization could coordinate with existing organizations such as the NRCS, the Fairbanks Soil and Water Conservation District, the Cooperative Extension Service, the Northern Alaska Environmental Center, the Interior Alaska Beekeeping Association, the Fairbanks Garden Club, and school programs. The organization could serve as a source of volunteers to help implement many of the suggestions in this plan. One of the first steps to establishing a nonprofit organization is to create a name and logo for the organization, which could involve grades K-12 in a competition for best name and logo. I will start a Facebook page to post information on local actions to protect pollinators. If a nonprofit is formed, they can take over maintenance of the site. More information can be found on how to start a nonprofit organization here: https://www.boardeffect.com/blog/checklist-for-starting-a-nonprofit-organization/

If there is not enough interest to start a sustainable nonprofit, the Natural Resource Conservation Service, the Fairbanks Soil and Water Conservation District, and the Cooperative Extension Service should be contacted to see if they could provide some or all of the functions that such a group could provide.

Potential Partners:	The NRCS, the Fairbanks Soil and Water Conservation District, the Cooperative Extension Service, the Northern Alaska Environmental Center, Interior Alaska Beekeeping Association, teachers in the Fairbanks School District, university and high school students, and other interested members of the public.
How to measure progress:	Funding base established, Board of Directors established, staff hired, strategic plan written, activities reported at required annual membership meeting and in annual report.

Objective B – Expand educational programs for Grades K-12

School gardens provide an opportunity to integrate classrooms and group activities of any age with outdoor activities and pollinator education. Creating and maintaining a pollinator garden connects students with the natural world, and provides hands-on experience with planning, math, biology, horticulture, health, and physical education. Connecting with other gardeners, horticulturists, or other professionals in the area is one of the best ways to learn about pollinator gardens. Below is some more information on how to create a curriculum and pollinator garden.

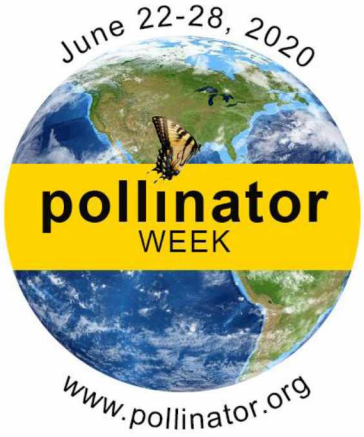
Local schoolteachers and youth group leaders (scouts, 4-H, afterschool clubs, etc) should be provided professional development opportunity related to pollinators and their connection to the Alaska State Science Curriculum standards and made aware of the following national resources:

- Pollinator Partnership provides a list of curricula, education tools and helpful links, including a Bee Smart® School Garden Kit targeted to students in grades 3 to 6 which is available for sale. Their Pollinator Gardening Curriculum is a PDF curriculum packet with lesson plans and activities for pollinator garden education. https://www.pollinator.org/
- The U.S. Fish & Wildlife Service provides pollinator related outreach and education materials as well as a schoolyard habitat guide. https://www.fws.gov/pollinators/
- Pollinator LIVE offers links to a series of live interactive webcasts, satellite field trips, and web seminars about pollinators, gardening, and conservation. Pollinator LIVE provides lesson plans for PreK through grade 12. https://pollinatorlive.pwnet.org/
- Project Learning Tree is focused on environmental education and has an Alaska chapter with courses available. They have examples of school projects that help pollinators thrive and also provide grants for service projects like school gardens. https://www.plt.org/
- Encourage people of all ages to learn about bumble bees and to join BUMBLE BEE WATCH to record their sightings. https://www.bumblebeewatch.org/

Potential Partners:	Fairbanks North Star Borough School District, University of Alaska Fairbanks Cooperative Extension 4-H programs, local environmental education non-profits, etc.
How to measure progress:	Document the number of educators reached through professional development, evaluate learning outcomes among youth participating in delivered pollinator lesson delivery, track number of activities on the Facebook page (Fairbanks, Alaska Pollinator Protection Plan).

Objective C – Celebrate Alaska's Pollinator Week

In June 2019, Governor Dunleavy signed an Executive Proclamation establishing June 17-23 as the official Alaska Pollinator Week (the National Pollinator week is June 22-28. The Proclamation acknowledged the vital role pollinators play in the health of the forests, grasslands and other unique ecosystems which provide forage, fish and wildlife, timber, recreational opportunities, and crop production. Alaska Pollinator Week will provide an opportunity to encourage the protection of pollinators, increase the quality and amount of pollinator habitat and restore pollinator populations. Pollinator Week activities nationwide are listed on pollinator.org and a Pollinator Week Toolkit can be downloaded from their website to help plan activities. Local beekeepers suggested including a "Local Honey Festival" as part of this week's events.



- Seek out potential partners
- Organize an event(s) during the week
- Document the event

Potential Partners:	Fairbanks North Star Borough (including Pioneer Park), the City of Fairbanks, the Fairbanks North Star Borough School District, the Northern Alaska Environmental Center
How to measure progress:	Event held yearly, number of participating organizations, number of Fairbanks community members in attendance, number of additional pollinator week activities on the Facebook page.

Objective D – Become the first city in Alaska to become a designated Bee City

Bee City USA is a program that endorses a set of commitments, defined in a resolution for creating sustainable habitats for native pollinators. This program incorporates communities into a joint effort to support pollinators. Since 2012, 105 communities have become certified "Bee Cities" and 95 college campuses are certified "Bee Campuses." Bee City USA disseminates information regarding funding information, pollinator research and habitat enhancement, and allows shared annual reporting of conservation results. More information on the benefits on becoming a Bee City affiliate can be found at https://www.beecityusa.org/benefits-to-your-community.html

- Typically, a non-profit organization (NGO) facilitates the process, working with the city government
- The NGO would approach the Mayor and City Council of Fairbanks (or the Mayor and Borough Assembly) to see if they are interested in applying to become a designated Bee City
- The NGO, in cooperation with the City, would complete the Application Form and Resolution Template (see website)
- The City would designate a city department as a Sponsor

- Working with the City, the NGO would draft a Bee City USA resolution and review it with Bee City USA headquarters (the resolution must be approved by Bee City USA before the city council adopts it)
- The NGO then submits the Application & Resolution to the City Council (or Borough Assembly) for approval
- The Bee City USA Designation is finalized by submitting the application, the adopted resolution, and fee payment to Bee City USA

Potential Partners:	Interior Alaska Beekeepers Association, Interior Alaska Beekeeping (Facebook group), The Northern Alaska Environmental Center, City of Fairbanks
How to measure progress:	Progress could be based on the above steps in the application process

GOAL 2: Develop and enhance pollinator-friendly habitat in Fairbanks

In my survey, local beekeepers were also very concerned about developing and enhancing pollinator habitat. Many had comments that echoed the views of this respondent:

Show people how beautiful a bee/pollinator garden can be.
– Survey Respondent

The most important requirement for pollinator protection and promotion is habitat (see Appendix B, Insect Pollinators, for more on this topic). In addition to flowers, some species of pollinators require nesting habitat and others require certain host plants for laying eggs and larval feeding. Without appropriate habitat, pollinators cannot survive, and it is important to discuss the actions the community can take to enhance and support pollinators and their habitat. Creating a better habitat for pollinators in Fairbanks includes many different projects that can be completed, such as a pollinator highway, bee gardens, nesting boxes, and pollinator garden kits. Appendix D provides a pollinator-friendly plant list (including host plants) that grow in the Fairbanks area and that attract pollinators.

Objective A – Create pollinator gardens on both private and public land

Pollinator gardens are one of the primary ways to improve pollinator habitat. "Bee Gardens" can be created around homes, businesses, golf courses, cemeteries, schools, public buildings and spaces, and on powerline easements, road medians, around airport runways, in vacant lots, etc. You don't even need to have a backyard—a few pots or a windowsill filled with pollinator-friendly plants will benefit pollinators.

"Any person who has even a postage stamp yard can stop using pesticides, put in more native plants… and leave some wild areas for bees to nest in the ground. It is that easy to help make a difference."

—Aimee Code, Pesticide Program Coordinator of the Xerces Society, quoted in the Great Barrington Pollinator Action Plan, p.49.

Gardens on Private Lands. To do so, incorporate a variety of native plants that attract pollinators and avoid using pesticides or herbicides. Each area has a different mix of native plants that are beneficial to pollinators, so it is necessary to find lists created locally. In Fairbanks, we are fortunate to have a list that was compiled by Dr. Pat Holloway, Professor Emeritus of horticulture at the University of Alaska Fairbanks, Department of Natural Resources & Environment. You'll find her pollinator-friendly plant list in Appendix D of this plan.

In their excellent free booklet, *The Native Pollinator Habitat Restoration Guide*, Schartz and Salisbury (2018) recommend locating pollinator gardens away from invasive weeds, stormwater pollution, pesticide application or drift, or areas where the garden might be mowed. Areas of bare ground should be included within your garden for ground nesting species. While native plant species are preferred, non-native plants may be used if deemed non-invasive.

Consider providing official "Pollinator Friendly/Pesticide Free" signs to place in local pollinator gardens, or homeowners and agencies could purchase their own, such as this one, available on Etsy.

https://etsy.me/2VV5FMo

They suggest starting with at least 10 types of flowering plants and planting 3 or 4 plants of a species in clumps because a group of one species is easier for pollinators to locate. Include plants that bloom at different times so that something is flowering throughout the season. It is also important to add structural diversity by including tall branching species, ground covers, shrubs and short and tall flowers that will form multiple vertical layers. Both woody and herbaceous plants should be included as well as annuals and perennials and different colors and forms of flowers (round, tubular, flat, etc.) to attract a wide diversity of pollinators. Larval host plants should also be included for moths and butterflies. While flowering plants are very important, some grasses and sedges should be included because they often serve as hosts and as nest sites for bumble bees and other beneficial insects.

Work with local nurseries to see if they are interested in offering seeds and plants from the list of possible pollinator-friendly plants shown in Appendix D.

Gardens on Public Lands. In addition to private gardens, there are many opportunities to create pollinator gardens on public lands. I spoke with several people regarding public gardens in Fairbanks. Michael Bork, Director of Parks and Recreation for the Fairbanks North Star Borough (FNSB) is in charge of all landscaping done for the Borough and was very interested in planting flowers that attract pollinators. He informed me that they plant thousands of flowers every year and they would be happy to include ones listed in this plan. Donnie Hayes, Manager of Pioneer Park, which is owned by the FNSB, was interested in planting demonstration pollinator gardens and installing an exhibit about pollinators and how to create your own pollinator garden. If it is possible to ensure the safety of visitors, they should consider having a honeybee observation hive.

Jeff Jacobson, Director of City Public Works for the City of Fairbanks was very interested in planting flowers that attract pollinators in the city-owned gardens if we provide a list of suitable plants. Katie DiCristina, Manager of the Georgeson Botanical Garden at the University of Alaska Fairbanks told me they already grow many flowers attractive to pollinators, but she is interested in installing signs and possibly including a pollinator garden. Each of these managers told me they do not use pesticides or herbicides in their plantings.

Each of these managers told me that they have a "no pesticide policy" that was instituted at the department level. Of these, the Borough Parks and Recreation Department manages the largest area; it does the landscaping for school buildings, all Borough buildings and 23 Borough parks. All of these

could include plants beneficial to pollinators as well as demonstration gardens (the Noel Wien Library already has a pollinator garden on the grounds).

I also spoke with Jackson Fox, the Executive Director of the nonprofit Fairbanks Area Surface Transportation (FAST). They maintain the landscaping next to all major roads within the urbanized portions of the Borough. Mr. Fox expressed interest in using pollinator friendly plants in their plantings. FAST does not currently have a policy on pesticides and herbicides but Mr. Fox is willing to bring that issue before his Board of Directors. Other public agencies and land managers should be contacted about including pollinator gardens (and possibly demonstration gardens with interpretive signs) in landscaping at their buildings as well as any public areas they manage. These include, but are not limited to, the University of Alaska Fairbanks, the Bureau of Land Management, the National Park Service, the Alaska Department of Natural Resources regional office and their state parks in the area, the Alaska Department of Fish and Game regional office and the adjacent Creamer's Field Migratory Waterfowl Refuge. The Fairbanks Downtown Association plants flowers in the downtown area and they may also be interested in including plants attractive to pollinators. The Fairbanks International Airport may be interested in reducing mowing around runways enough to increase bloom time of plants like clover and dandelions and adding pollinator plants to flower boxes and other plantings.

Install a bee hotel in your garden. Bee hotels are nesting boxes made with various natural materials to simulate solitary nesting sites which attract a variety of bees. Typically, holes are made in wood to provide room for solitary bees to lay their eggs, or in the photo at right, bamboo tubes were used. Instructions on how to make pollinator nesting boxes can be found here https://pollinators.msu.edu/publications/building-and-managing-bee-hotels-for-wild-bees/ or you can purchase nesting boxes online.

https://modernfarmer.com/2017/02/build-native-bee-hotel/

Once created, **pollinator gardens** should be registered at the website http://millionpollinatorgardens.org/. The organization Million Pollinator Gardens set out to register one million pollinator gardens and surpassed their goal in just a few years, but they are still adding to their list. Registration lets people know where the pollinator gardens are in a city and this information helps link them into pollinator corridors. There are currently two gardens registered in Fairbanks, including one private garden and the garden around the FNSB's Noel Wien Library.

Potential Partners:	Local nurseries, horticulturists, landscape professionals, school projects, Pollinator Week Activities, the Fairbanks North Star Borough and their parks, the City of Fairbanks, the Georgeson Botanical Garden, UAF, the Alaska Dept of Natural Resources (and state parks), the Alaska Dept of Fish and Game, Creamer's Field Migratory Waterfowl Refuge, the Bureau of Land Management and the National Park Service
How to measure progress:	• Square meters planted per year (plus the cumulative total). • Number of registered bee gardens in the area (currently there are 2) • Number of new locations of pollinator gardens posted on the Facebook page Fairbanks, Alaska Pollinator Protection Plan.

Objective B – Establish a Pollinator Highway in downtown Fairbanks

Pollinator corridors are pesticide-free pathways of largely native plants that provide food and habitat for pollinators. These corridors are designed to connect pollinator habitats and reduce stressors such as habitat destruction, habitat fragmentation and isolated colonies. Habitat fragmentation occurs when a large expanse of habitat is transformed into several patches of a smaller total area, isolated from each other by habitats or structures that are not like the original (Fahrig, 2003). Isolated colonies of pollinators experience less genetic diversity and vitality. Corridors can help pollinators expand into new territory (Schwartz el al., 2018). Bumble bees and honeybees can travel more than a mile, but small pollinators may travel no more than a few hundred feet, so they need habitat areas that are close together. Schwartz and Salisbury recommend connective corridors or gardens of flowering plants less than 500 feet apart for small pollinators and up to two miles for bumble bees. There are many types of potential corridors including trailsides, roadsides, and power line corridors.

One potential pollinator corridor in the Fairbanks area is the 4 km (2.5 mile) Chena Riverwalk between Pioneer Park and Griffin Park, shown in Figure 4. This highway could provide native plants that attract pollinators as well as the water, shelter, and resources they need to thrive. Benefits of this area include patches of existing pesticide-free flower planting beds maintained by local residents, private businesses and the City and Borough, many native flowering plants, and non-native flowering trees and shrubs, and long stretches of undeveloped riparian habitat between the river and the walkway. Two additional parks, Jenel Thompson and Growden, would also be linked by this corridor. The popular recreational path also offers a unique opportunity to demonstrate the types of plants that benefit pollinators and to post interpretive signs that raise awareness about the problems affecting pollinators and how people can help protect them. For more information on pollinator pathways, visit https://www.pollinator-pathway.org/.

A University student or an agency such as the Fairbanks Soil and Water Conservation District could prepare an interpretive plan for the corridor to ensure that the signs are accurate, attractive, appropriate for the audience and that they cover the key points the public should know about pollinators. In the long term, the city could have many interconnected pollinator corridors.

Figure 2. Potential pollinator pathway. Source: Google Earth.

Potential Partners:	Fairbanks North Star Borough, Pioneer Park, the Northern Alaska Environmental Center, Volunteers, Proposed Fairbanks pollinator protection non-profit.

How to measure progress:	Report the area of pollinator habitat planted along the corridor each year until most of the path is lined with pollinator habitat. Report the progress on writing an interpretive plan and implementing it. Survey recreational users of the pathway measuring changes in their awareness before and after walking the path.

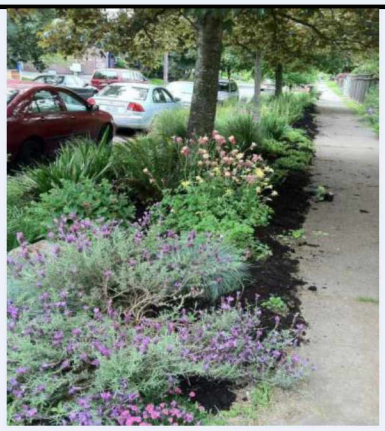
Seattle's Pollinator Pathway

Seattle has been working on a one mile long 12-foot-wide pollinator corridor since 2009. Through a collaborative effort with homeowners their pathway connects two green spaces, Nora's Woods and Seattle University campus. Along the pathway connecting these green spaces there are twenty sites that are each individually funded. A cohesive design connecting green spaces was accomplished using primarily native plants, and astute garden design taking into account city requirements, human enjoyment, pollinator appeal, and ease of care.

Nora's Woods

Seattle University campus

Pathway green spaces



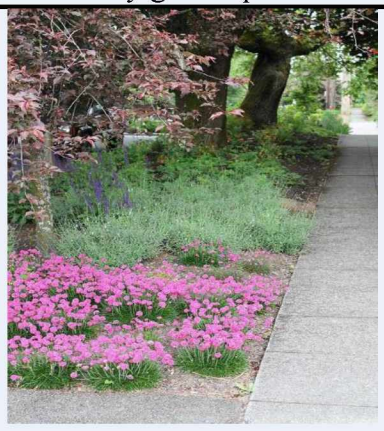


Figure 3. Seattle's pollinator pathway. http://www.pollinatorpathway.com/active-projects/the-first-pathway/#pilot-overview

Objective C – Leave areas of natural habitat

Homeowners and public lands should leave some logs, clumps of rotting leaves, dead standing trees, and dry dirt patches to serve as nesting grounds for bumble bees, solitary bees, beetles, and several other types of pollinators.

- Most native bees nest underground in areas that are bare or lightly vegetated in sunny, well-drained locations. Others nest in wood, empty cavities. and hollow stems.

- Leave logs, hollow stems and standing dead trees to serve as habitat for pollinators and other organisms
- Put aside some piles of dead leaves to provide food and shelter for bees, beetles, moths and butterflies.
- Where possible, minimize lawn mowing practices to maximize bloom time of flowering plants, including dandelions and clover. This saves money while also benefitting pollinators. Use signs on public natural lawns to raise awareness and hold a "Natural Lawn Contest" for public and private landowners. See the website https://dontmowletitgrow.com/ for more on the benefits of reducing mowing and ways to raise awareness.

Maintaining a frequently-mowed path while mowing the rest of the lawn less frequently allows flowers like clover and dandelions to grow, creating the look of a wildflower meadow.

Great Barrington Pollinator Action Plan, p. 50. http://bit.ly/2TTb2ZM

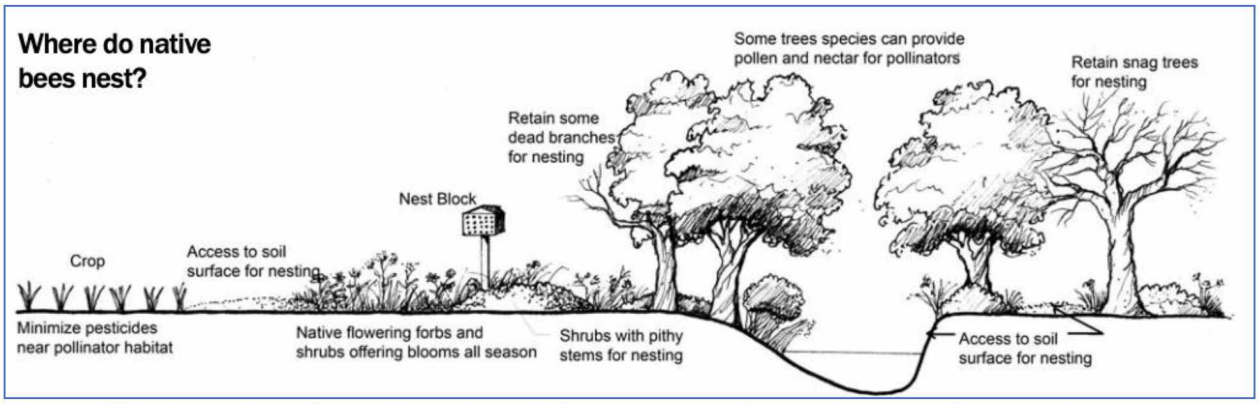


Figure 4. USDA National Agroforestry Center. (2007) Enhancing nest sites for native bee crop pollinators. p.1.

Potential Partners:	NRCS, FSWCD, Cooperative Extension, City of Fairbanks, homeowners, landscape companies
How to measure progress:	Number of local lawns adhering to pollinator friendly practices. Number of contestants entering the Natural Lawn Contest.

GOAL 3: Minimize the use of pesticides harmful to pollinators

Pesticide use was the chief concern of the beekeepers surveyed for this plan. Of the 30 respondents, 28 (93%) gave pesticides a 5 out of 5 as the most harmful threat to pollinators. This was the most agreed upon answer throughout the survey. Herbicides rated as the second highest factor negatively affecting pollinator health; 19 (63%) of respondents rated herbicides as very harmful. Herbicides can kill food sources such as dandelions that is an important source of nourishment in early spring for an assortment of pollinators.

"We have seen a very severe impact by the amount of mosquito sprayers in the vicinity. As they have gone up, our instances of colony collapse have increased." —Beekeeper Survey Respondent

Minimizing the use of pesticides is an important step in conserving pollinator health. Information on how to report pesticide incidents can be found at:

- How to Report Pesticide Incidents Involving Wildlife or the Environment by the EPA
- How to Report a Pesticide Incident Involving Exposures to People by the EPA

Objective A – Increase awareness of alternatives to insecticides

Most insecticides do not discriminate when controlling insect populations, however, the control agent can be designed to be more effective against targeted species. Nevertheless, non-lethal effects of pesticides can be just as devastating, such as, damaging the navigation centers in honeybees which renders them unable to return to their hive leading to their eventual death. However, there are other pollinator-friendly methods to control insects. For more information on biological alternatives to harmful chemical pesticides visit: https://www.cbd.int/doc/case-studies/tttc/tttc-00147-en.pdf. Herbicides can kill food sources such as dandelions that is an important source of nourishment in early spring for an assortment of pollinators.

Aphids

- Many wasp species and ladybug larvae prey on the soft bodied aphids; therefore, design your garden using plants that attract lady bugs or wasps which will feast on the aphids.
- Spray essential oils, Neem oil is effective at deterring several types of insects, however, neem oil can be harmful to fish and other aquatic life, so it is recommended not to apply near lakes, rivers, or ponds. You will also need to reapply once a week or after rain.
- Spray soaps such as diluted dish detergent. However, care is to be taken as harsh soap solutions may harm plant life. It is best to test before applying over the whole garden.

Wasps

Although wasps are beneficial pollinators and as well as exterminators of other pests, they can also pose a potential threat to families with young children or people with allergies. We must not destroy wasps as they are an integral part of the ecological system in our environment. However, there are steps you can take to reduce the chances of having wasps take up residence in your yard.

- Remove attractants such as pet food, bird feeders, and food scraps.
- Grow wasp repellant plants in areas frequented outdoors with such as mint, citronella, thyme, eucalyptus, and wormwood.
- Spray essential oils, Neem oil is effective at deterring several types of insects, however, neem oil can be harmful to fish and other aquatic life, so it is recommended not to apply near lakes, rivers, or ponds. You will also need to reapply once a week or after rain.
- Spray soaps such as diluted dish detergent However, care is to be taken as harsh soap solutions may harm plant life. It is best to test before applying over the whole garden.
- Hanging a decoy or false wasp nest

Mosquitoes

Anyone who has lived or visited Alaska knows that in summer the mosquito rules the outdoors. The mosquito is a very hardy insect that is tough to control.

- Remove any containers that can be sources of standing water where mosquitoes breed
- Sterile Insect Technique is an environmentally friendly method which involves the mass-rearing of target pests and sterilization using radiation. Afterwards, the targeted sterile males pests are systematically released by air over defined areas, where they mate with wild females resulting in no offspring and a declining pest population. For more information on this technique please visit this website: https://www.iaea.org/topics/sterile-insect-technique
- Use mosquito repellant

Potential Partners:	Interior Alaska Beekeepers Association, University of Alaska Fairbanks Cooperative Extension Service, University of Alaska Fairbanks Cooperative Extension 4-H programs, private residence, Fairbanks North Star Borough School District, local environmental education non-profits, etc.
How to measure progress:	• Record retailers that label or stop providing insecticides. • Document voluntary education about reducing insecticides. • Record voluntary reduction of insecticide use by private residence and businesses. • Track the use of insecticides by the North Star Borough (FNSB indicated that insecticides are currently very rarely used by Borough departments).

Objective B – Increase awareness of alternatives to herbicides

Herbicides are used by many landscape managers, homeowners, and railroads to control weeds. They are often used in areas prior to planting pollinator gardens. However, there are pollinator-friendly methods to control many invasive weeds.

For best results weeds should be removed before they produce seeds.

- Weed torches – Always be aware of fire hazards when using this method
- Mulch is a layer of material applied to the surface of soil. In addition to reducing weeds, mulching can retain surface moisture and improve soil fertility.
- Ground covers are low-growing plants that have minimal maintenance requirements. Dense growing species can be used to choke out weeds. More on appropriate ground covers for the Fairbanks area can be found at the end of Appendix D.
- Using various weed removing tools, such as a fork-tongued weed remover
- Pulling weeds by hand

For more information on organic site preparation for pollinator and other gardens, as well as details on many alternatives to herbicides, visit: https://xerces.org/sites/default/files/2018-05/16-027_02_XercesSoc_Organic-Site-Preparation-for-Wildflower-Establishment_web.pdf

Dandelions and clover are friends to pollinators

Dandelions are probably one of the most widely despised plants. However, dandelions are one of the first sources of nourishment for both native and non-native pollinators in late spring and early summer, so eliminating them has a negative impact on pollinators. Although it will require a paradigm shift, it would be helpful to raise public awareness of the benefits of dandelions and clover for pollinators. The flowers should be allowed to bloom before mowing.

Photo by Scott Bauer, USDA Agricultural Research Service Image Library.

Potential Partners:	Interior Alaska Beekeepers Association, University of Alaska Fairbanks Cooperative Extension Service, University of Alaska Fairbanks Cooperative Extension 4-H programs, private residence, Fairbanks North Star Borough School District, local environmental education non-profits, etc.
How to measure progress:	• Record retailers that label or stop providing herbicides. • Document voluntary education about reducing herbicides. • Record voluntary reduction of herbicide use by private residence and businesses. • Track the use of herbicides by the North Star Borough (FNSB indicated that herbicides are currently very rarely used by Borough departments).

Objective C – Incentivize pollinator-friendly businesses

Businesses for Bees—American Business Collaboration for Pollinator Conservation Action (https://www.pollinator.org/biz-for-bees) is a national and international association of businesses dedicated to expanding and supporting pollinator health. Some of their objectives are listed below.

- Create a peer-to-peer network of businesses that commit to taking action to foster the recovery and sustainment of pollinators and their habitat;
- Engage our employees, our customers, our communities, and our industries in this effort.
- Utilize management approaches that will ensure a sustainable future for pollinators;
- Support science; and
- Actively engage in sustainable actions.

Many businesses based in the Lower 48 states (including Home Depot and Lowes) have joined this group and volunteered to label products or stop carrying certain products that are known to be toxic to pollinators. The collaboration does not require a financial commitment but does look for support from its members in building pollinator actions. New applicants are subject to the approval of founding Business for Bees companies. Any business can join by contacting the email address on their homepage. (https://www.pollinator.org/biz-for-bees).

Our community could encourage local businesses to join Businesses for Bees. As an additional benefit, the Friends of Fairbanks Pollinators could adopt a Pollinator Friendly Initiative sticker (example below) to give to these businesses to communicate their pollinator-friendly commitment to customers. These businesses could be listed on the Fairbanks Pollinator Protection Facebook page and included in publicity for Pollinator Week events.

Figure 5. Example pollinator friendly certification logo. Graphic design by: Samuel E. Adams

Potential Partners:	Fairbanks Soil & Water Conservation District, Local businesses, Fairbanks Chamber of Commerce, Fairbanks Downtown Association, Rotary Clubs
How to measure progress:	Number of local businesses that join Businesses for Bees.

Objective D – Minimize the risk of pesticide drift and contamination

At times, pesticides may be necessary to control invasive plants and animals.

- One of the best ways to reduce impacts is for anyone using a pesticide to read and follow all label recommendations for the product's use and to remember that pesticide labels are legally required documents.
- It is important to notify beekeepers in the area several days before applying any pesticides so they can take precautionary steps to protect their hives. However, a survey respondent told me, "The Mosquito Authority would notify people they were going to spray. Then they would spray, and it killed bees. There is no way to protect them other than not spraying within a few miles of each hive." Research should be done to verify just how far pesticides can drift. If they do spread that far, then perhaps the only way to protect bees will be public pressure and perhaps a local ordinance or statewide legislation prohibiting all but spot treatments for mosquitos.
- To avoid water contamination and to minimize drift onto flowering plants where pollinators are found, make sure there are buffer zones between areas of application and sensitive habitats and water bodies.
- Reduce spray drift further by spot treating and applying pesticides only under calm conditions.
- Pesticides should be applied while bees and other insects are less active, such as before or after blooming periods, or in late afternoons and evenings. Additionally, scout for pollinator presence before applying a pesticide to ensure they are not in the area. (Fish and Wildlife Service, 2013)
- For more information on using pesticides near pollinators visit: https://www.fws.gov/pollinators/pdfs/Reducing_Risks_to_Pollinators_from_Pest_Control_factsheet.pdf
- The Alaska Department of Environmental Conservation has information on pollinators and mosquito control: https://dec.alaska.gov/eh/pest/mosquito-spraying-and-honeybees/
- The US Environmental Protection Agency has information on pesticides and pollinators here: https://www.epa.gov/pollinator-protection
- The National Pesticide Information Center from Oregon State University has reviews of specific pesticide active ingredients (e.g. 2,4-D, glyphosate) and their toxicity to bees and other environmental considerations. However, commercial products (e.g. Weed-B-Gone, Roundup) contain more than the active ingredient and those additives may increase toxicity, so the label is the final guide. Nevertheless, the fact sheets for pesticides at OSU provide a guide to assessing an active ingredient for any environmental concerns you may have.

Potential Partners:	Landscape businesses, homeowners
How to measure progress:	Record the amount of spraying activities shared through the Beekeepers' Association communication channels. Additional such as follow up questions for beekeepers asking if communication honeybee mortality, as well as what protective actions beekeepers used to protect their hives after the communication. Record management practices that have been altered by individuals and businesses to reduce pesticide drift and contamination.

WEBSITE RESOURCES

Alaska Department of Natural Resources Interior Alaska Revegetation Plan:
http://plants.alaska.gov/pdf/interior_reveg_web.pdf

Biological Alternatives to Harmful Chemical Pesticides:
https://www.cbd.int/doc/case-studies/tttc/tttc-00147-en.pdf

Fritz Creek Gardens offers many native plant species for Alaska.
alaskahardy.com

National Conference of State Legislatures: State Laws on Pollinators. Twenty-two states have passed legislation to protect pollinators. A summary of this legislation can be found on this site.
https://www.ncsl.org/research/environment-and-natural-resources/pollinator-health.aspx

Native Pollinator Habitat Restoration Guide:
https://www.earthcorps.org/wp-content/uploads/The-Native-Pollinator-Habitat-Restoration-Guide-EarthCorps.pdf

Pellett, F.C., *American Honey Plants, 5th ed*., (1976). 476 pages. Hamilton, IL. A definitive list of plants for horticultural and urban forestry purposes that produce abundant nectar flows to support honey crops. Check with the USDA Forest Service list of invasive plants in Alaska before planting
https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev2_037726.pdf

Selected invasive plants of Alaska. USDA Forest Service.
https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev2_037726.pdf

Xerces Organic Site Preparation for Wildflower Establishment
https://xerces.org/sites/default/files/2018-05/16-027_02_XercesSoc_Organic-Site-Preparation-for-Wildflower-Establishment_web.pdf

Xerces Pollinator Resources. This site includes a wealth of information on pollinators.
https://xerces.org/pollinator-conservation-resources/107

POTENTIAL SOURCES OF FUNDING

FEDERAL PROGRAMS:

Agricultural Conservation Easement Program (ACEP), Using Farm Bill Programs for Pollinator Conservation https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/easements/acep/

Natural Resource Conservation Service (NRCS): Conservation Stewardship Program (CSP) https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/csp/ and Environmental Quality Incentives Program (EQIP) https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip/

U.S. Fish and Wildlife Service: WSFR - Assisting States with Monarch Butterfly and Pollinator Conservation https://www.fws.gov/wsfrprograms/Subpages/Pollinators/Pollinators.htm

US Department of Agriculture (USDA): Conservation Reserve Program (CRP) https://www.fsa.usda.gov/programs-and-services/conservation-programs/conservation-reserve-program/, Conservation Reserve Enhancement Program (CREP) https://www.fsa.usda.gov/programs-and-services/conservation-programs/conservation-reserve-enhancement/index

NGOs:

Kids Gardening provides information on many upcoming grants which could be useful depending on your project, location, and timing. https://kidsgardening.org/

Seedmoney.org provides community groups with small starter grants to beautify their town or neighborhood

The "Feed a Bee" program offers grants for projects that benefit pollinators https://www.feedabee.com/

The Green Education Foundation provides a green thumb challenge grant of $250 for organizations to support sustainability and youth gardens http://www.greeneducationfoundation.org/greenthumbchallengesub/green-thumb-challenge-winners.html

The National Forest and Wildlife Foundation offers a Monarch Butterfly & Pollinator Conservation grant supporting habitat improvement, outreach and organizational coordination https://www.nfwf.org/programs/monarch-butterfly-and-pollinators-conservation-fund

The Pollination Project provides seed grants of $1,000 to promote sustainable projects. https://thepollinationproject.org/

Wild Ones offers a $500 grant through their Seeds for Education (SFE) Grant Program for school and non-profit organizations. https://wildones.org/seeds-for-education/

OTHER:

Multiple businesses like Home Depot, Lowe's, and others provide grants or may donate materials to garden projects and schools. Please contact your local business to see how they may be willing to help.

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APPENDIX A: Review of Twelve Pollinator Plans

My first step in writing this plan was to review 12 pollinator plans. I wanted to include a variety of plans at the city, county and state level. It was more difficult to find plans than I anticipated. I found a total of thirteen plans. I rejected the West Sussex County Council Pollinator Action Plan 2019-2022 because it was created by simply copying sections from other pollinator plans and did not include original work. Wyoming did not have a pollinator plan, but it did have a guide to improving habitat on private land called, "Promoting Pollinators on Your Place: A Wyoming Guide." It is not a plan because it did not have goals and objectives, nor did it call for specific actions to occur by a certain time. However, the guide was rich in suggestions for improving habitat and many of these suggestions could be incorporated into my plan, so I wanted to keep it in the list.

Table A1. City, county and state plans reviewed for this project, in alphabetical order by location.

CITIES	COUNTIES	STATES
-Great Barrington, Massachusetts -Madison, Wisconsin -Toronto, Ontario	-Boulder County, Colorado -Dane County, Wisconsin -Somerset County, the United Kingdom	-Maryland -Missouri -New York -Texas -Wisconsin -Wyoming

Criteria for evaluating each plan

Dr. Susan Todd (2019) compiled the list of plan review criteria based on 35 years of experience working and teaching in the field of resource planning. These steps include identifying issues, conducting a resource inventory, engaging the public, and writing a vision statement and goals that state the long-term purpose of the plan. Then there are the steps that call for specific actions. These are often called objectives and targets. The last step is to write indicators to measure progress in reaching each target. Within each step, there are fairly consistent guidelines on what to include. For example, targets should be measurable and include who is to do what by when. The targets should also help meet the objective they are under. Plans also need to be user friendly or the general public is unlikely to read them.

Since this project was focused on pollinators, criteria were added that apply to pollinator plans. In pollinator plans, the issues and inventory steps are covered by the pollinator science sections where they discuss the current status of local pollinators and the problems they face. After reading through all the plans, I particularly liked those that included sections on pollinator science, a list of potential funding sources, resources for additional information, and literature cited, so I added those as additional criteria for evaluating the plans.

Table A2. List of criteria for evaluating each plan.

Plan Review Criteria
1. Public Engagement Was the public involved? If so, how (include details)?
2. Vision Is there something that qualifies as a "vision statement" that applies to the entire plan? (they do not always call it a vision). If so, a) Is the vision statement adequately idealistic? It should be something that may never be attained. b) Is it in present tense as though it were already true? c) Is it vivid and easy to picture? d) Is the wording engaging? e) Would "most" people find it inspiring? (one person's inspiration may be another's nightmare) f) Does the wording make sense or is it just fluffy words strung together? g) Do you have any other comments, critiques or suggestions on the plan's vision?
3. Goals and Objectives Does the plan have something that qualifies as what I would call goals and subsequent objectives? (they may use different terminology). If so, a) Does each statement explain both what should be done? b) Will these goals help reach the vision? c) Many planners believe goals should not be attainable. After all, "our reach should exceed our grasp, or what's a heaven for?" (Robert Browning). Do these goals seem to be easy to accomplish, or very challenging? d) Does each start with an action verb? e) Is each goal and objective a complete sentence? (A complete sentence should have a subject and a verb and make sense standing alone. This helps avoid ambiguity.) f) Do the goals focus on an END POINT more than on how to get there (which is purpose of the lower levels)? g) Does the wording make sense or is it just fluffy words strung together? h) Will the objectives help reach the goals? Do they complete sentences that start with action verbs? i) Are the objectives call for specific actions? j) Did the plan include targets for when an action should be completed? k) Did it include ways to measure progress and indicate who should do what by when?
4. Overall Organization a) Does the plan a clear organization? b) Does it include a table of contents? c) Are the vision and subsequent levels well organized and easy to follow?
5. User Friendliness a) Does the plan present data to support the need for the plan, and to help determine what steps need to be taken to solve the issues? b) Is the data (if included) presented in a way the general public can understand?

c) Do you think the data they included were essential to explain why they proposed certain actions and to win support for the plan as a whole?
d) Can you imagine the plan being as effective without including the data?

6. Funding Opportunities

One section I liked in some of the plans was funding opportunities for individuals, groups, schools, business and municipalities. This is important because without funding, most of the actions within a plan can be implemented, so I added this criterion.

a) Were there funding opportunities provided within the plan?
b) Were the funding opportunities easy to find?
c) Does the plan include multiple resources for diverse organizations?

7. Additional Resources

Sections that listed additional resources (primarily websites) were included in some pollinator plans. This seemed like a valuable addition to any pollinator plan to provide information that is too detailed to include within the plan.

a) Did the plan include additional resources and if so, were they easy to find?
b) Did the resources include credible information?
c) Was there a wide variety of additional resources?

8. Pollinator Science

One additional trait that I included in the review was pollinator science. This is an important component to pollinator protection plans by providing information on local pollinators. All pollinator plans provided some version of pollinator science sections, however, there are some particular traits which I searched for within the plans.

a) Does the plan include information on pollinators within the plans designated geographic range?
b) Does the plan include information such as nesting and foraging habits, and life cycles of local pollinators?
c) Does it cite reliable sources?

9. Research References

Did the plan include a reference section that lists sources of literature cited in the plan and other useful works?

Once I had the criteria and the plans, I wrote detailed notes regarding how well each plan met the criteria. But detailed notes on twelve plans can be a bit overwhelming. To help identify the top plans, I scored the plans on how well they met each individual criterion. This was a way to translate considerable qualitative information into a quantitative measure. I chose a three-point scale because it would be difficult to judge the plans in finer detail, which a five-point or higher scale would require. For example, I gave a zero to plans that did not include a criterion (such as a pollinator science section), a 1 to a plan that did an adequate or almost adequate job on the pollinator science section, and a 2 to a plan that did an outstanding job on that section. By summing the scores for each criterion, it was possible to rank the plans from highest to lowest score. These scores are not precise, but taken together, they do help distinguish between plans with low, middle and high total scores. Then I could focus more attention on the top plans when I started working on my own plan. The plans are listed in order from highest to lowest total score in Table A4, at the end of this Appendix.

To demonstrate how each criterion was scored, here is an example of how I scored 3 of the 12 plans on one criterion: their pollinator science sections. The first column lists the plan, the second contains my notes regarding the criterion, and the last lists the score I gave it. The original table included notes and scores on 9 criteria for each of the 12 plans. This took several pages in 11x17 inch format and a small font, but I can provide the full table if desired.

Table A3. Notes and scores for one criterion: What did you like best/least about their section on pollinator science? What aspects, if any, would you want to emulate, and which would you want to avoid?

Plan	Notes on this criterion (Pollinator Science)	Score 0-1-2
Great Barrington, MA. Pollinator Action Plan, Winter 2018	Besides the basic explanation of plant biology and the process of pollination, the pollinator science section includes information n on bee habitat, and another on lepidoptera habitat. The pollinator science section also offers habitat types for three groups of bees: wood-nesting bees, ground-nesting bees, and social bumble bees. The list provides a short synopsis of nesting and foraging habits for the bee categories. They include the foraging distances of different pollinators in relation to prime pollinator habitat locations suggested during town hall meetings. I particularly like this quote: *"If you meet the forage, shelter, and overwintering needs of a diverse community of native bees, you will create habitat for other pollinators as well (Mader et al., xi)." (Pg. 10)* This is the same idea I have for this plan; however, it is good to have the reference. I want to find the article mentioned.	2
Pollinator Habitat Conservation Activity Plan for Boulder County, Colorado. 2017	Pollinator science is not presented in one section, but fragmented throughout the plan. There are some good parts, for example, page 28 indicates the pests that farmers have found on their farms and lists the natural enemies of the pests and some habitat information for beneficial insects. However, the plan would benefit from having a pollinator science section that could be referenced throughout the plan instead of breaking the information up throughout the plan.	1
Somerset County, UK. Council Pollinator Action Plan 2018-2028	The plan did not offer much information on pollinators, only some statistics on decline rates in Europe. Nor does the plan specify what a "good" pollinator habitat consists of. This is an important consideration when informing the residents on how to improve existing plans for the benefit of pollinators.	0

Below I list each plan in order from highest to lowest total score, some background about the plan, and a summary of its strengths and weaknesses. The scores I gave each plan on the nine criteria are shown in Table A4 at the end of this Appendix.

Plan 1: Toronto Pollinator Protection Strategy *Score: 15*

The Toronto Pollinator Protection Strategy is a draft document created in 2017 and developed with help from experts, stakeholders and concerned residents of Toronto. This document, they say, will become a part of a broader Biodiversity Strategy. The city of Toronto did not provide information for the funding of this plan. Toronto implements multiple plans which focus on habitat, so most of the actions in this plan will provide co-benefits for other plans being implemented in the city. Several bee species are at risk of extinction in Toronto; developing this plan will increase their support of pollinators and hopefully stop their decline. This document was supported by many stakeholders, experts, and concerned citizens. The draft strategy will be used for further public consultation. https://www.toronto.ca/wp-content/uploads/2018/05/9676-A1802734_pollinator-protection-strategy-booklet.pdf

Strengths

Toronto provided a beautiful plan which can be made into a pamphlet. Throughout the plan, Toronto produced graphics emphasizing interesting facts about pollinators. This plan also presented success stories throughout the document. Strong emphasis on native pollinators and the amount of effort they put into involving the community.

Weaknesses

No table of contents. There are no citations for the information included in the plan. There are no clear funding opportunities presented for future projects for schoolchildren, homeowners, or businesses. Instead, the plan indicates that the reader should contact them for more information on how the city can help create pollinator habitat.

Plan 2: The Wisconsin Pollinator Protection Plan *Score: 15*

The April 2016 Pollinator Protection Plan for the state of Wisconsin was created by the Department of Agriculture, Trade and Consumer Protection (DATCP). The development of this plan was funded by a USDA Specialty Crop Block Grant (Pg. I). DATCP partnered with researchers from the University of Wisconsin, Madison to gather information from stakeholders to guide plan development. The DATCP initiated the pollinator protection plan in 2014 when there were growing concerns about pollinator declines, honeybee health and crop production. Pollinator-dependent crops account for over $55 million in annual production in Wisconsin. The DATCP pollinator protection plan has been put in place to protect pollinator diversity, honeybee health, and crop production. https://datcp.wi.gov/Documents/PPPComplete.pdf

Strengths

The Wisconsin planning effort was led by an entomologist, an apiarist and a pesticide program manager. They assembled a diverse advisory group of 31 stakeholders (they list their names and affiliations in the appendix). The advisory group helped conduct 3 public meetings in the state and write the plan. The plan includes a good introduction with 4 main goals.

The Wisconsin plan is broken down into four chapters which also act as independent documents that can be given to diverse audiences: homeowners with lawns and gardens, beekeepers, farm managers and conservation practitioners. The content, graphics and extensive reference lists in

these documents are excellent and might be something we could recommend to similar audiences in Fairbanks.

Weakness

No vision. The plan includes four basic goals, but no objectives, targets or indicators. After the goals they state, "Because this plan is voluntary and directed at a broad array of audiences, the impacts of its recommendations are not easily tracked. Implementing the plan is not something any one person, organization or industry can do alone. Our collective actions will determine how successful these plan concepts are realized, and ultimately contribute to the future health of managed and wild pollinators." (pg.10). While they did not try to develop indicators to track progress, their advisory group did propose several metrics that might be used (pg.49). I was surprised at the lack of metrics in the plan, though I can see that some of the actions taken as a result of the plan might be hard to track. Finally, the plan provides excellent information on pollinators in general, but I would like to see more information on specific local pollinators.

Plan 3: Dane County Pollinator Report *Score: 14*

The Dane County, Wisconsin Pollinator Protection Plan was created in 2015 by the Dane County Pollinator Protection Task Force. The plan did not provide a vision; however, an organized set of goals, objectives and actions were presented in the plan. This dedicated task force devised four primary goals: education and outreach, maximize pollinator-friendly habitat and outreach, minimize pesticide hazards, and long-term pollinator research.
https://drive.google.com/file/d/0B1h2eS9fzbyPdE1aV3ZRSUZJZzg/view

Strengths

Part II of the plan is the first strong point of this plan. Part II provides four goals. Each goal contains multiple objectives. Objectives are broken down into Recommended Actions, Evaluation of Actions, Barriers that actions might encounter, and Possible Leaders for completing the actions. This allows the plan to be broken down into solvable increments. Assigning leaders gives responsibility to completing an action. Part III provides recommended actions for each department in the county. The recommendations were created following departmental briefings where each department was given questions related to agricultural practices that might influence pollinator health (EX Pg. 19). Answers to these questions gave the task force an idea of what each department is doing for pollinator health in the county and provided the basis of their recommendations. Some of their recommendations are quite demanding, for example, one recommendation for the Land & Water Resource Department is to establish pollinator habitat on new land acquired or managed by the Parks Department (I wish they would specifically say ALL new land) (Pg. 14). A detailed pollinator protection budget recommendation is presented on page 16 for Dane County based on answers from departmental briefings.

Weaknesses

The primary weakness is that the Task Force did not involve the larger community in the planning process, although members of the public were on the Task Force. Also, the pollinator science section is lacking information on local pollinator species and habitat requirements which can limit the effectiveness of pollinator habitats and the plan. The plan also lacks a list of funding opportunities for the public and other business in the community.

Great Barrington, Massachusetts is a town that is setting its sights high by creating a pollinator action plan and becoming the first municipality in New England to pass a Pollinator Friendly Resolution in 2018. The Pollinator Action Plan was created in collaboration with the Town of Great Berrington Department of Public Works, The Great Berrington Department of Public Works, The Great Berrington Agricultural Commission, the Conway School of Design, and stakeholders across the region. Great Barrington is situated in the Housatonic River Valley and continues its long history of agriculture practices. The community of Great Barrington recognizes the global pollinator declines and has decided to act. The plan is committed to building a local movement. The Great Barrington plan is designed to be an educational toolkit to be used by anyone with an interest in promoting pollinators in the Northeast United States. Most of the plan is dedicated to sharing knowledge of pollinators and their habitat, demonstrative gardens, and providing plans to create gardens that are wild but look lovely. https://www.townofgb.org/sites/greatbarringtonma/files/uploads/greatbarringtonpollinatoractionplan2018.pdf

Strengths

The Great Berrington plan starts with "building a local movement." This section provides the goals of the plan and what they hope to achieve. The various strengths of this plan include the history of Great Berrington, pollinator science, landscape mapping, and how to create pollinator habitats. The plan provides a history of their town showing where they came from (turning the Housatonic River into a sewer) to being one of the top twenty small towns in America (named by the Smithsonian magazine, 2012). This section gives strength to the plans primary purpose, change, showing readers that the town has worked hard to become a beacon of good environmental management. Public involvement is one of the greatest strengths of the plan. The public meetings allowed the planning team to select locations around the city that overlap pollinator ranges connecting them (as shown on Pg.12). Opportunities in Great Berrington is a section that incorporates the plan's main goals of visibility, scalability, and manageability on public lands to create a roadmap for pollinators though the city (Pg. 35). This is where the plan reveals great graphics and photos of the community. The pictures and graphics are of existing conditions, followed by another picture of what that property could look like after establishing a pollinator habitat (Pg. 37). This provides a vision for readers. The point of these and other demonstrations provide a strategy and information to better inform the municipality and the community on how to establish pollinator habitats and implement the plan where and when possible. The demonstrations are supported by later sections like planning a pollinator network and a toolkit.

Weaknesses

No vision which would be a succinct statement of what they want to achieve. For the plan to demonstrate a clear structure and direction on what they would like to achieve and how they will achieve it, the goals and objectives should be clearly stated in the beginning of the plan rather than sprinkled throughout the document. Some of the graphics in the plan are unclear due to the low resolution of the picture (most notably on pg. 11). The plan does not provide any time sensitive targets or indicators, nor do they provide baseline information on the areas slated to become pollinator friendly habitats when the plan is implemented.

Plan 5: Missouri Monarch and Pollinator Conservation Plan *Score: 14*

This plan was Prepared by the Missourians for Monarchs Collaborative Steering Committee and is designed to be implemented from May 1, 2016 to April 30, 2019. The document is published on the Missouri Department of Natural Resources webpage. Missouri is geographically located within the migratory path and spring breeding area of the monarch butterfly. This species has declined significantly over the past twenty years. Many factors have affected the monarch population including habitat loss in the US, climate change, and a significant decrease in milkweed, the plant that monarchs depend on for nourishment and brooding areas. The milkweed plant has decreased significantly in Missouri which is why this plan calls for the urgent improvement of habitat for the monarch butterfly.
https://dnr.mo.gov/education/documents/MOforMonarchs-ConservPlan.pdf

Strengths

The plan includes clear goals, objectives, targets and indicators which should increase the likelihood that the plan will be implemented.

Weaknesses

The vision stated in the plan "Missourians will learn to appreciate" sounds aggressive and needs to be revised (pg.4). The Missouri plan should provide clearer structure between sections and goals. There are no funding opportunities presented in the plan, only that funding should be obtained for different actions.

Plan 6: Maryland Pollinator Protection Plan *Score: 13*

This document is intended for the state of Maryland and was completed in June of 2016. The Maryland Department of Agriculture developed this document due to the declining pollinator health across the country, putting 1/3 of the nation's pollinator dependent crops risk. The development of this plan was made possible in part by the USDA Specialty Crop Block Grant Program.
https://mda.maryland.gov/plants-pests/Documents/MarylandPollinatorProtectionPlanRevised.pdf

Strengths

Public engagement was one element this plan incorporated very nicely. They included over 70 stakeholders representing state agencies, beekeepers, growers, pesticide applicators, landowners, and land managers. Although the Maryland plan does not have a table of contents, the sections are easy to pick out and the document gets right to the point, giving the reader many reasons to implement the plan and how to do so through their goals, objectives and actions.

Weaknesses

The Maryland plan did not provide citations for the scientific information they included in the plan. I would also like to see a more complete pollinator science section.

Plan 7: City of Madison Pollinator Protection Report *Score: 12*

The City of Madison Pollinator Protection Report was created in 2014 by the City of Madison Pollinator Protection Task Force and was updated in 2015. This document is designed to be used by all city departments on city-owned lands. After reviewing departmental practices, the task force provided guidance for long-term pollinator health strategies. This plan does not provide a vision for the future; however, they do have goals for the plan which include: review of departmental practices affecting pollinator habitat and health, recommendations to improve pollinator habitat on city-owned land, and guidance to each department for a long-term strategy to promote pollinators.
https://www.cityofmadison.com/mayor/documents/Pollinator%20Protection%20Task%20Force%20Report%20FINAL%203-24-16(1).pdf

Strengths

The task force used departmental surveys to collect information on the current practices of city departments on city land related to pollinator health and provided recommendations where the Task Force believed they could improve. The recommendations begin on page 25, where the plan lists timelines for each action they recommend. Each department receives a section of recommended actions. These actions are followed by a time frame "Short: 1-2 years, Medium: 2-3 years, or Long: 3+ years". The recommendations tell the reader who is to do what by when, and are organized by type, including Policy, Education, Public Lands Management, and Partnership recommendations. The City of Madison Charter document on page 36 brings all of these recommendations together and holds leaders accountable for implementing them. I believe that this document will be a good reference for the future.

Weaknesses

The title page does not contain a title for the document. The plan should expand their pollinator science section informing readers what pollinators are, local species, foraging habitats, and nesting habitat requirements. This would give city employees the reasons for taking these actions and also help them identify pollinators, their habitat, and potential nesting sites. Madison also did not involve the community in the planning process.

Plan 8: Promoting Pollinators on Your Place: A Wyoming Guide *Score: 12*

The Wyoming Guide was created in 2017 and funded by the Wyoming Department of Agriculture Specialty Crop Program. This guide is packed with useful information on pollinators in Wyoming, and ways to improve pollinator habitat in backyards, landscapes, farming, and beekeeping. The guide provides many websites and other resources, and a table of contents which gives the reader a clear structure of the plan. The guide also supplies blocks of text and graphics that are interesting and relevant to each section. This guide is user-friendly and easy to read.
http://www.uwyo.edu/barnbackyard/_files/documents/resources/pollinators/pollinatorguide.pdf

Strengths

This guide contains multiple strengths in information and presentation. One strength is the pollinator science section. The pollinator science section provides a surplus amount of information on what pollinators are, types of pollinators in Wyoming, their habitat, nesting requirements. Readers can take this information and learn how to create conditions that are favorable to pollinators in general or use it to attract specific types of pollinators. Another strength is the Promoting Pollinators on Your Place section which focuses on the need to have something blooming throughout the season for your pollinator habitat. They give some questions to consider when creating a pollinator habitat such as: "At what elevation are

you?", "What kind of year is it?", "Are your plants in a sunny, warm area, or in a cooler, shadier area in your yard?", and "How much do you irrigate?" These are great questions to ask when creating a pollinator garden and could be the beginning of a useful pollinator garden checklist. There is a calendar provided that specifies what times of year certain pollinators are buzzing around to help determine when to plant and what to plant for your pollinator garden. There is also a list of plants for pollinators with their bloom periods. The last strength of this guide is the beekeeping section. This segment of the guide covers many things a person would need to know to start their own hive. Three appendices provide a great deal of information as well.

Weaknesses

This is a guide, not a plan, because it does not provide a vision, goals, objectives, targets or timelines. Instead of calling for actions and specifying who is to do what by when, this is simply a guide for landowners and landscapers on how to create pollinator habitat. The purpose of this plan is to inform interested parties about pollinators and their needs and what individuals can do. Although it is not a plan, I think many of the guidelines in this document would be useful to include in pollinator plans.

Plan 9: Pollinator Habitat Conservation Plan for Boulder County, CO Score: 9

The Boulder County Pollinator Conservation Activity Plan was released in 2017 by the Xerces Society for Invertebrate Conservation and has been created to "conserve pollinators in general for all of the benefits they provide and to serve as a model for conserving/enhancing pollinator habitat on farms in the area" (Pg. 4). https://assets.bouldercounty.org/wp-content/uploads/2018/01/pollinator-habitat-conservation-plan.pdf

Strengths

This plan provides information for farmers that would like to strengthen natural pollinator populations on their property for their crops. Native pollinators are more effective at pollinating plants than managed bees and wind (for crops that are able to wind pollinate); therefore, increasing native pollinator populations could raise crop yield. Practices recommended in this plan include: identifying beneficial insects that are needed for the farm in question, what threats those pollinators are under, how to mitigate those threats, and how to promote pollinator health and population on the property. The plan provides modified NRCS habitat enrichment codes that have been suited to pollinator needs. After each potential action there are recommended plants to seed for pollinator habitats. Another strong point is information on habitat establishment and maintenance guidelines. The information presented there lets the reader know site preparation methods, planting methods, and short-term and long-term management practices. Table 2 on page 28 lists pests found on the Ertl Farm (a demonstration farm that has adopted many of the recommendations) along with their natural enemies, and habitats for attracting those insects.

Weaknesses

Two main weaknesses are found in this plan, the lack of a pollinator science section and user friendliness. Pollinator science information is scattered throughout the plan. This weakness means readers need to skip back and forth through sections when trying to remember what a previous section explained. The plan would benefit from having a pollinator science section that is more detailed and that could be referenced throughout the plan. The plan provides a considerable amount of uninterrupted text that may exhaust readers. Pollinator enrichment methods are listed throughout the plan to help farmers create their own goals, objectives and targets for their farm; however, the plan lacks instructions on how to do that. They

should include one paragraph at the beginning of each section to explain how to apply this portion to the reader's farm.

Plan 10: New York State Pollinator Protection Plan *Score: 8*

The New York State Pollinator Protection Plan was created in June 2016 by the New York Department of Environmental Conservation. The Pollinator Protection Plan (PPP) is a state-wide plan for the conservation and promotion of pollinators. According to the plan, New York State has lost more than 50% of managed pollinators overall and commercial beekeepers have lost 70% of their hives. Migratory pollinators are also down by almost 70% (pg. 1). This, coupled with the losses of native pollinators and the habitat that sustains them, led the Department of Environmental Conservation in New York State to develop this plan. https://www.dec.ny.gov/docs/administration_pdf/nyspollinatorplan.pdf

Strengths

The New York State plan provides important information regarding multiple levels of pollinator protection. The New York State Pollinator Protection Plan provides yearly updates on progress.

Weaknesses

There was no public involvement for the creation of this plan and it is also weak in user friendliness and overall organization.

Plan 11: Somerset County Council Pollinator Action Plan *Score: 6*

Somerset County lies in southwest England and their County Council developed the plan in 2018. The Somerset Pollinator Action Plan has three primary goals: to protect and increase the quality and amount of pollinator habitat and greenspace that is managed by the council, to raise awareness of the plight of pollinators, and to ensure the consideration of pollinator health in council, landowner, and business agricultural practices.
https://democracy.somerset.gov.uk/documents/s8491/Somerset%20Pollinator%20Action%20Plan%20Draft.pdf

Strengths

The Somerset plan clearly indicates their vision and goals, while "aims and actions" indicate how they will achieve their vision. The Somerset County Council emphasized their commitment to collaboration, care and respect, customer focus, and a can-do attitude. Some actions provide information such as who will do what action, but fail to include when that action should be completed.

Weaknesses

The Somerset pollinator action plan lacks important information in their pollinator science section. They have no mention of the types of pollinators in Somerset other than a general term of bees, or native pollinators. The weakness of the plan is compounded by the lack of information on habitat requirements of the different pollinators. This information gap could lead to the failure of actions and objectives. Some of the actions of this plan do not provide instructions/information/resources on how to complete tasks.

Plan 12: Texas Monarch and Native Pollinator Conservation Plan *Score: 6*

The Texas Monarch and Native Pollinator Conservation Plan was created in April 2016 by Texas Parks and Wildlife Department. Texas Parks and Wildlife department recognized that monarch populations have had a significant decline in recent years. They initiated the plan to protect monarchs migrating through Texas and to improve their health and the health of native pollinators throughout the state. Monitoring of overwintering monarch populations began in 1993. Since then, populations reached an all-time low of 35 million in 2013, compared to 1 billion in 1996. These declines in population and habitat loss have fueled many conservation efforts in order to help monarch populations—including this plan (pg. 4). https://tpwd.texas.gov/publications/pwdpubs/media/pwd_rp_w7000_2070.pdf

Strengths

The Texas Monarch and Native Pollinator Conservation Plan conducted an inventory of current habitat conservation and management activities being implemented by various organizations with access to public lands. They mention using the information and advice of citizen scientists in developing the plan, which I think is a good idea (Addendum B. Pg. 16).

Weaknesses

There is no vision in the plan. The Texas Monarch and Native Pollinator Conservation Plan goals are:

- Habitat Conservation
- Education and Outreach
- Research and Monitoring
- Partnerships and Collaboration

Each goal should be a complete sentence that starts with an action verb. These goals do not meet those criteria. Goals should also be followed by more specific objectives that help meet the goals. Habitat conservation was the only goal that provided objectives. Most goals only provided actions that the Texas Parks and Wildlife Department (TPWD) was going to implement. They did not include partners. The public was not engaged in the development of the plan. This document is an internal plan for what the TPWD will do to increase monarch butterfly populations and wild pollinators. There are not many actions citizens would be able to implement. But the TPWD does refer landowners to another document to help them develop a wildlife management plan for their property that includes pollinators, which might allow them to qualify for a tax incentive.

Table A4. Scores for each plan on each criterion. Total score possible = 18.

Plans were scored from 0 (criterion was not met), 1 (criterion was met to some extent), to 2 (criterion was fully met).										
Pollinator Plan	*Public Engagement*	*Vision*	*Goals and Objectives*	*Overall Organization*	*User Friendliness*	*Funding Opportunities*	*Additional Resources*	*Pollinator Science*	*Research References*	***Total Score***
Plan 1: Toronto Pollinator Protection Strategy	2	2	2	2	2	1	2	2	0	**15**
Plan 2: The Wisconsin Pollinator Protection Plan	2	0	2	2	1	2	2	2	2	**15**
Plan 3: Dane County Pollinator Report	1	0	2	2	2	2	2	1	2	**14**
Plan 4: Great Barrington Pollinator Action Plan	2	0	1	2	1	2	2	2	2	**14**
Plan 5: Missouri Monarch and Pollinator Conservation Plan	2	1	2	2	1	0	2	2	2	**14**
Plan 6: Maryland Pollinator Protection Plan	2	0	2	2	2	2	2	1	0	**13**

Plan 7: City of Madison Pollinator Protection Report	0	2	2	2	0	2	1	1	2	**12**
Plan 8: Promoting Pollinators on Your Place: A Wyoming Guide	0	0	2	2	2	2	0	2	2	**12**
Plan 9: Pollinator Habitat Conservation Plan for Boulder County, Colorado	1	0	2	1	0	2	0	1	2	**9**
Plan 10: New York State Pollinator Protection Plan	0	1	1	0	1	1	0	2	2	**8**
Plan 11: Somerset County Council Pollinator Action Plan	1	2	1	0	0	1	0	1	0	**6**
Plan 12: Texas Monarch and Native Pollinator Conservation Plan	0	1	1	0	1	1	0	1	1	**6**

APPENDIX B: Background on Insect Pollinators

One aspect that I really enjoyed from researching the 12 pollinator plans was learning about the local pollinators in each area. Some of the plans like Great Berrington, and Wisconsin provided pollinator science sections which were very detailed and inspired me to want to emulate their enthusiasm for local pollinators in this plan. The purpose of this appendix is to serve as an educational tool on pollination, and common varieties of pollinators found in the Fairbanks area. Appendix B includes general pollinator information, common species of pollinators found around the Fairbanks area, their foraging habits, habitat requirements, and life cycles.

Alaska is home to many insect pollinators including bumble bees, non-native pollinators (European honeybees), wasps, flies, butterflies and several more. According to the United States Department of Agriculture Natural Resource Conservation Service (NRCS, n.d.), there are 49 species of bumble bees in North America, 23 of which are found in Alaska. For a better understanding of insects and their role in pollination we will examine the basic anatomy of a flower. Cross pollination occurs when pollen from one flower's anther (the male portion of the flower) is transferred to the stigma (female portion of the flower) of another flower thus fertilizing the plant for reproduction. Pollination can be achieved through wind (some crops, trees, and most grasses), water movement (for aquatic plants), and animal visitation to flowers or inadvertent movement. Pollen is the protein source for insect colonies which helps nourish broods and lead to a healthier colony. Nectar, which is also produced by the flower, is the energy source for bees during foraging. Insect pollinators forage for pollen and nectar from a diverse array of wildflowers, fruits, and crops.

Understanding insect pollinator foraging habits are a great way to find out how to attract the kind of pollinator you desire for your garden, roadside, field, crop, etc. Attracting pollinators is a combination of habitat, timing, and morphological considerations. Pollinators and plants are directly affected by their environment. When the environment is unfavorable for the plant, or pollinator, there may not be a successful integration (Armbruster et al., 1989). The seasons at which plants bloom, or pollinators are active, should be considered as well. The selected plants for pollinator projects should provide blooming for consecutive seasons, as well as last throughout the pollinators active season. Finally,

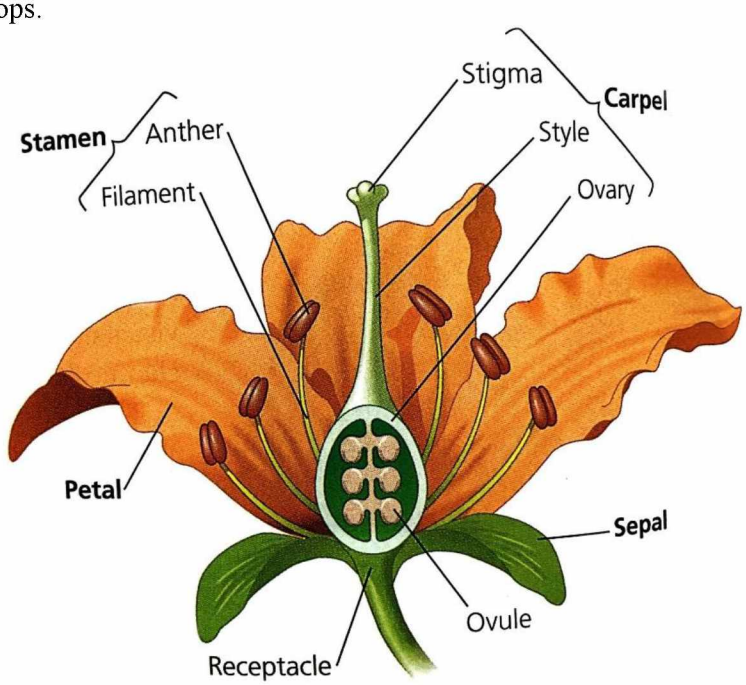


Figure 6. Reece J. et al. Campbell Biology 10th edition page 816

Did you know?

Some crops, such as almonds are totally dependent upon managed honeybees which must be present in order to achieve adequate pollination to produce almonds.

pollinators are influenced by floral morphology that may render nutrients unreachable (Armbruster et al., 1989). The availability of nutrients, quality, and reward dispersion all influence the floral preferences of the pollinators (Armbruster et al., 1989). These processes generally apply to all species of insect pollinators that we will mention in this plan.

In farming, crop yield and quality are constantly improved as pollinator flower visitation increased (Bartomeus et

al., 2014). The observed pollinator species richness was negatively affected by agricultural intensification; however, flower visitation patterns did not suffer with intensification (Bartomeus et al., 2014). This observation may have been caused by the presence of honeybees. Honeybees are managed pollinators and do not depend heavily on the landscape of agricultural areas for nesting habitat. In contrast, native pollinators depend on surrounding habitat to nest and forage for other nutrients during non-blooming times of the crops to survive through the year. Therefore, the introduction/re-introduction success of additional suitable pollinators into an agricultural system is dependent upon the habitat (Bartomeus et al., 2014). The addition of more pollinator species, given that they are provided with an adequate habitat, would lead to more crop flower visitation and optimize pollination, thus improving crop yield and quality (Bartomeus et al., 2014). Another advantage of facilitating native pollinating species is the independence from honeybees. Farmers who depend on beekeeper pollination services could become independent of their services as well as secure their future in case the pollination services by managed pollinators become unavailable. Complex landscapes of south facing bluffs, followed by roadsides, floodplains and crops provide the greatest bee species richness (Armbruster et al., 1989; Bartomeus et al., 2014). Heterogeneous landscapes offer a variety plant bloom periods which is essential for pollinator food sources throughout the year.

Bombus polaris feeding on flower blossom. Photo by Joaquim Alves Gaspar, from Wikimedia

Bumble Bees (*Bombus*)

The NRCS estimates there are 23 species of bumble bees (*Bombus* spp.) in Alaska (NRCS, n.d.). Bumble bees are social insects that need constant nourishment for colony growth (Rao et al., 2012). Colonies develop over several months; however, blooming plants only last a portion of that time (Rao et al., 2012). This highlights the importance of multiple flowering species of plants that bloom in succession for the duration of the colony's development. These plants supply the bees with a continual source of nourishment and prevent the death of the colony (Rao et al., 2012).

Bumble bees are generalist pollinators. A generalist pollinator visits a diverse array of flowers, with different morphologies, rewards, and bloom times. Bumble bees employ a technique that is unique to their species called "buzz pollination". This action is achieved by flexing their flight muscles inside of the flower to release pollen (NRCS, n.d.). Nesting habitats for bumble bees are found in the ground. These are typically mouse burrows, empty bird nests, discarded mattresses, manure piles, and in the walls of abandoned houses (NRCS, n.d.). Bumble bees often forage along tree lines, fields, and south facing

Wild bumble bee nest. Photo by Victoria MacPhai, from xerces.org

bluffs. The bumble bee has a large foraging radius according to Rao et al. (2012), the average bumble bee worker travels 11.6 kilometers.

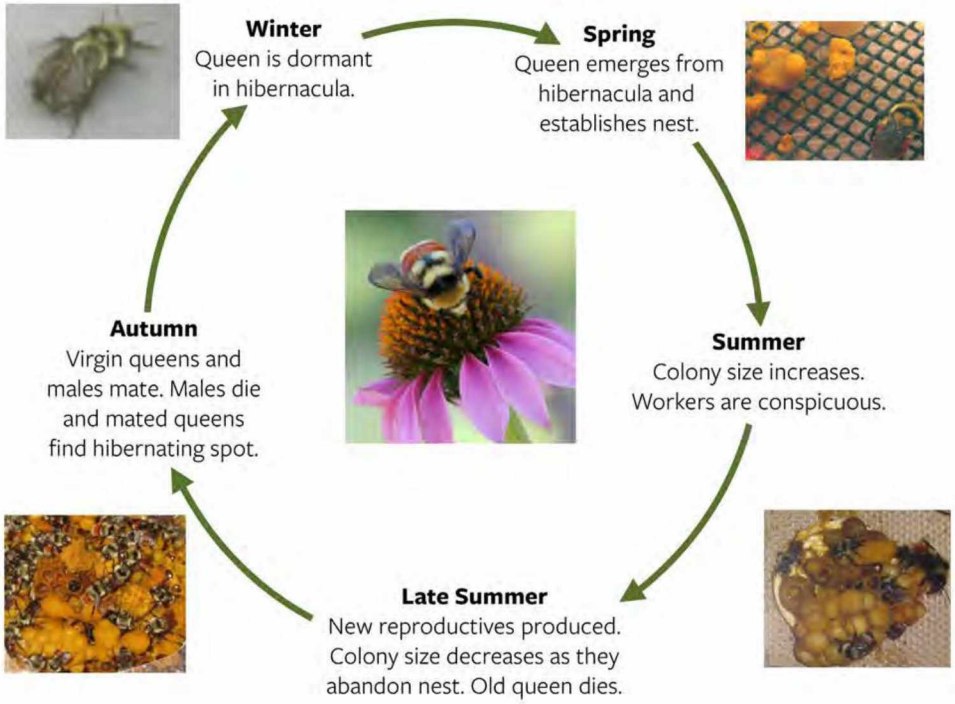


Figure 7. The life cycle of B. huntii. James Strange, USDA-ARS.

BUMBLE BEE LIFE CYCLE

- In spring, the young queen bumble bee emerges from her winter hibernacula (a small cavity usually excavated in the soil). The queen then feeds on nectar from early blooming flowers such as dandelions. Afterwards, the bee searches for a suitable nest site to rear her brood.
- Once a suitable site for a nest is found, the queen makes a wax honey pot to hold nectar (food collected for herself) while she raises her first daughters. The queen actually incubates her eggs by bringing her hairless abdomen into contact with them and shivering to generate body heat. She can maintain their temperature between 75 and 93 Fahrenheit while the air temperatures around her in the nest are as low as 37 F. The eggs will hatch on top of a ball of pollen the queen gathered to feed her first brood of larvae.
- Once the first daughters become adults, they start to forage on flowers to gather more pollen and some nectar. The daughters also assist their mother in rearing more offspring. In the late summer, new queens and male bumble bees are reared. The elderly queen and worker daughters eventually die.
- The males leave the nest to mate with the new queens in the area and then die off, too. The new queens forage on late-season flowers to build up body fat. She also searches for a suitable place to dig a hibernaculum and hibernate for the winter (Schell et al., 2017).

European Honeybee (Apidae)

The European Honeybee is easily the most recognizable pollinator. They are also the only managed insect pollinators that produce honey. Originally, these bees were imported to North America from Europe in the early 1600's for honey production. Honeybees live in colonies which are housed in beehives. These boxes provide several accommodations including shelter from weather, and a place to brood and make honey. However, in the past fifty years, honeybee colonies have experienced progressive population loss.

Beehive box, Chumley, 2017

In Alaska, over nine million European Honeybees are imported each year for honey production due to unsuccessful overwintering and physiological limits of honeybees (NRCS, n.d.). Excess colony declines across the US fueled the Bee Informed Partnership (BIP) in 2006 which was formed to monitor colony losses. The BIP has recorded and published all reported losses nationally, in their report, every sequential year since 2006 losses have accelerated (Flottum, 2017). Beekeeper revenue has also changed throughout the years from 1988, where 11% came from pollination services, to 2016, where 41% of their revenue came from pollination services (Flottum, 2017). This drastic increase could be another indicator of the decline of pollinators and the increasing need for pollination as crop sizes increase (Flottum, 2017). For more information on beekeeping in Alaska check out http://alaskabeeclub.com/ or http://cespubs.uaf.edu/publications/

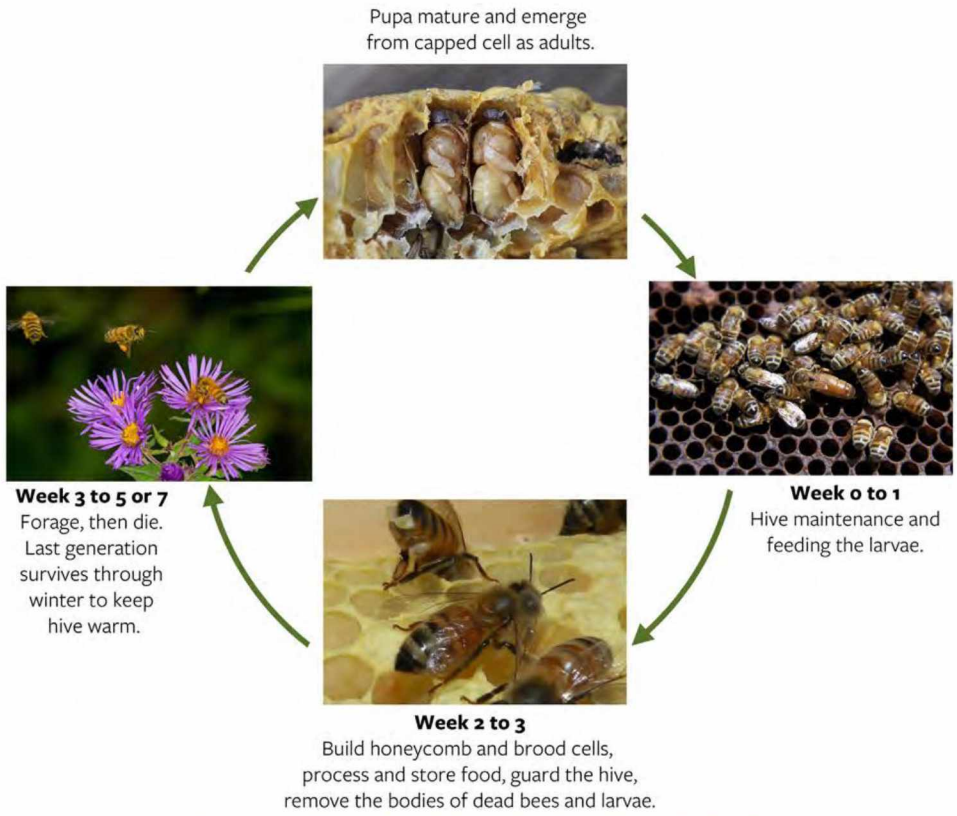


Figure 8. Honeybee life cycle. Schell et all. 2017.

HONEYBEE LIFE CYCLE

- The process from the egg, larval, and pupation into an adult worker honeybee is usually takes between 18 to 24 days.
- An adult worker bee starts out performing hive maintenance and feeding the larvae the first week.
- After two weeks, the worker bee begins building honeycomb and brood cells by secreting beeswax and shaping into hexagonal cells. They also receive food from foraging worker bees for processing and storage, guard the hive, and remove the bodies of dead bees and larvae from the hive.
- At three weeks, worker bees enter the last phase of their lives as foragers to gather the food stores needed to keep the colony alive during the winter. The worker bees produced in the spring and early summer die before they are 8 weeks old.
- The worker bees produced at the end of the summer live the longest. They will spend the winter eating honey and shivering to create enough body heat to keep the queen bee at a temperature at, ideally, over 94 F (Schell et al., 2017).

Solitary Bees:

Solitary bees are abundant and diverse in Alaska and consist of a variety of bee species such as the sweat bee, mining bees, digger bees, and many others. Solitary bees thrive in open sunny habitats at low elevations, especially in treeless subarctic steppes (south facing slopes) and habitats growing grasses, forbs, shrubs, and trees along floodplains and roads (Armbruster et al., 1989). Unlike bumble bees, the solitary bees have the lowest abundance and species richness in closed-canopy boreal forests and alpine tundra, these bees do not form large, socially organized nests (Armbruster et al., 1989; NRCS, n.d.). The solitary bee prefers warm sunny foraging habitats and nesting in exposed dry soil, these conditions favor south facing bluffs, roadsides and floodplains (Armbruster et al., 1989).

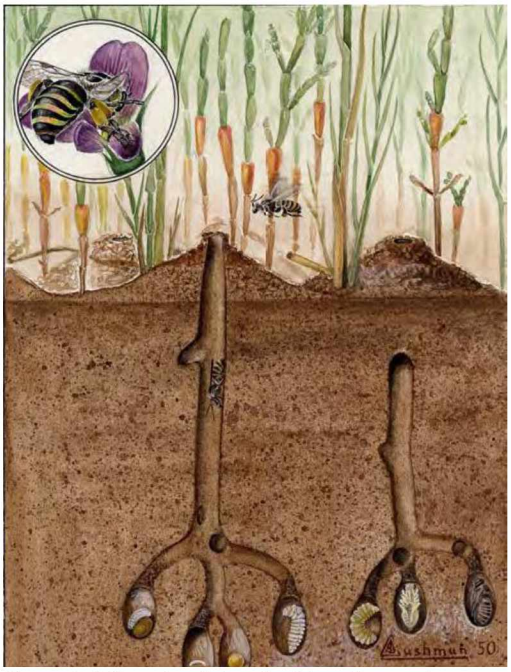


Figure 9. Life cycle of the alkali bee Illustration: Cushman, USDA Systematics Entomology Laboratory

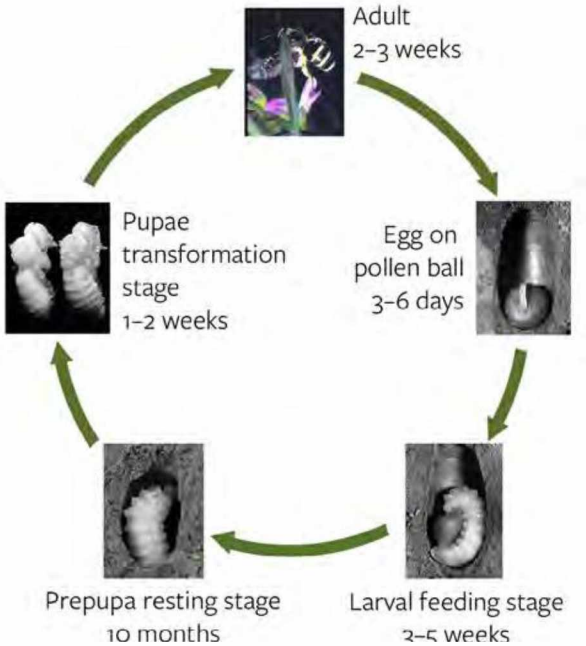


Figure 10. Life cycle of a solitary ground nesting bee. James Crane USDA-ARS

EXAMPLE OF SOLITARY GROUND NESTING BEE LIFE CYCLE

The alkali bee life cycle is an example of one of many ground nesting, solitary bee species.

- Male and female alkali bees spend the winter underground and pupate in individual brood cells that their mother dug and provisioned the previous summer.
- Rising soil temperatures and moisture levels trigger the emergence of the adult alkali bees, which should occur at the same time as the flowering of suitable food plants, usually starting in June.
- The female bees will forage as far as 5 miles to find bare soil that is critical habitat for their brood rearing tunnels. Male solitary bees mate with females as they excavate their tunnels and only forage for nectar for food for themselves.
- Once the main tunnel reaches an acceptable depth, the female excavates a brood cell and lines it with a water-resistant oral secretion. She then provisions it with a ball of pollen, deposits an egg, and seals the chamber off from the main tunnel. She does this, ideally, at the rate of one a day when abundant flowers are just a short flight away. Although she works by herself on her nest tunnels, many other alkali bee nests will be crowded into the same preferred soil habitat (Schell et al., 2017).

- **Sweat Bees**: Sweat bees are a diverse group of bees with a variety of social behaviors. Social behaviors are dependent on the time of year, geographic location, altitude and many other factors that are unknown (Buckley et al., 2011). Typically, nesting habitats for most sweat bee species are found underground, in rotting wood or in locations where the soil is exposed and undisturbed (Buckley et al., 2011). Subspecies of Halictids that are parasites do not build nests at all. Sweat bees are important pollinators for wildflowers and crops, including pome fruits, sunflowers and alfalfa (Buckley et al., 2011). Sweat bees have a small foraging radius of a few hundred yards, keeping to temperate sunny habitats near forbs and sparsely exposed soil.

An adult sweat bee. Photograph by Jeff Hollenbeck. (Buckley et al., 2011).

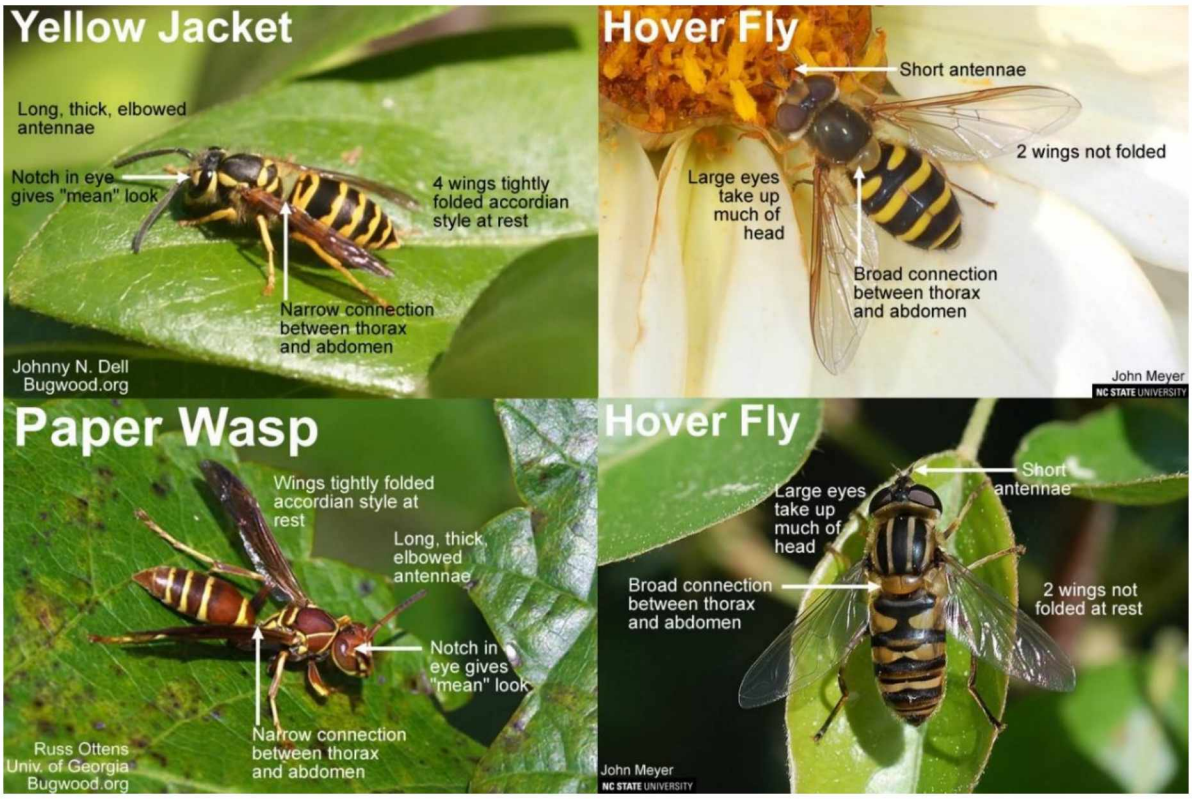
Vespidae: There are nearly 5,000 diverse species of wasps in the Vespidae family. Vespidae, or more commonly known as wasps, are categorically the most feared pollinators. Yet, wasps are one of the most beneficial pollinators. Wasps provide pollinating services to wildflowers, fruits and vegetables. A large portion of small wasp species serve as parasites to other insects, specifically caterpillars and aphids which feed on and destroy crops. Their ability to exterminate pests that are detrimental to crops along with their pollinating abilities make wasps irreplaceable to our environment and agricultural assets (NRCS, n.d.). These insects forage in many environments and are generalist hunters (Richter, 2000). Nesting sites of wasps are always enclosed in a papery substance and can be found underground, hanging from eves or tree branches, and in wall voids (NRCS, n.d.).

USDA Natural Resources Conservation Service n.d.

Hover Flies: Hover flies, otherwise known as flower flies, are known for their ability to hover in flight (NRCS, n.d.). Hover flies are among the most colorful and conspicuous insects. These flies cannot sting, instead they rely on their uncanny ability to mimic wasps or bees, thus fooling birds and other predators into avoiding them (Shepherd, n.d.). Hover flies do not build nests, instead they use their disguise to infiltrate the nests of wasps or bees to lay their eggs. Most often larvae are found in murky places, wasp and bumble bee nests, stagnant water, carcasses and about 40% of the world species eat aphids, scales, and other soft bodied pests in larval stages (Shepherd et al., n.d.). These pollinators forage near nesting grounds of other pollinators.

Hover fly. Photo by Alex Wild, www.myrmecos.net.

Below is a comparison between a yellow jacket (top left), a paper wasp (lower left) and a hover fly/flower fly (both figures on the right) to exemplify the hover fly's uncanny ability to mimic insect predators for defense against predators.



Butterflies (Lepidoptera)

Lepidoptera, is an order of insect that includes butterflies and moths. Butterflies and moths serve as general pollinators. Plant life is important to butterfly and moths as it provides nesting sites for eggs, nourishment at the larval stage, and nectar as an adult. Select species are dependent on host plants for food and nesting requirements. Lepidoptera larvae (caterpillars) consume plants for sustenance until undergoing the metamorphosis. Thereafter, feed on the nectar of flowering plants to provide energy to fly. In warmer climates, butterfly's typical lifecycle lasts three weeks, however, Alaskan butterflies are known to live for over a year (NRCS, n.d.). There are over 700 butterfly species in North America, 80 of which are found in Alaska.

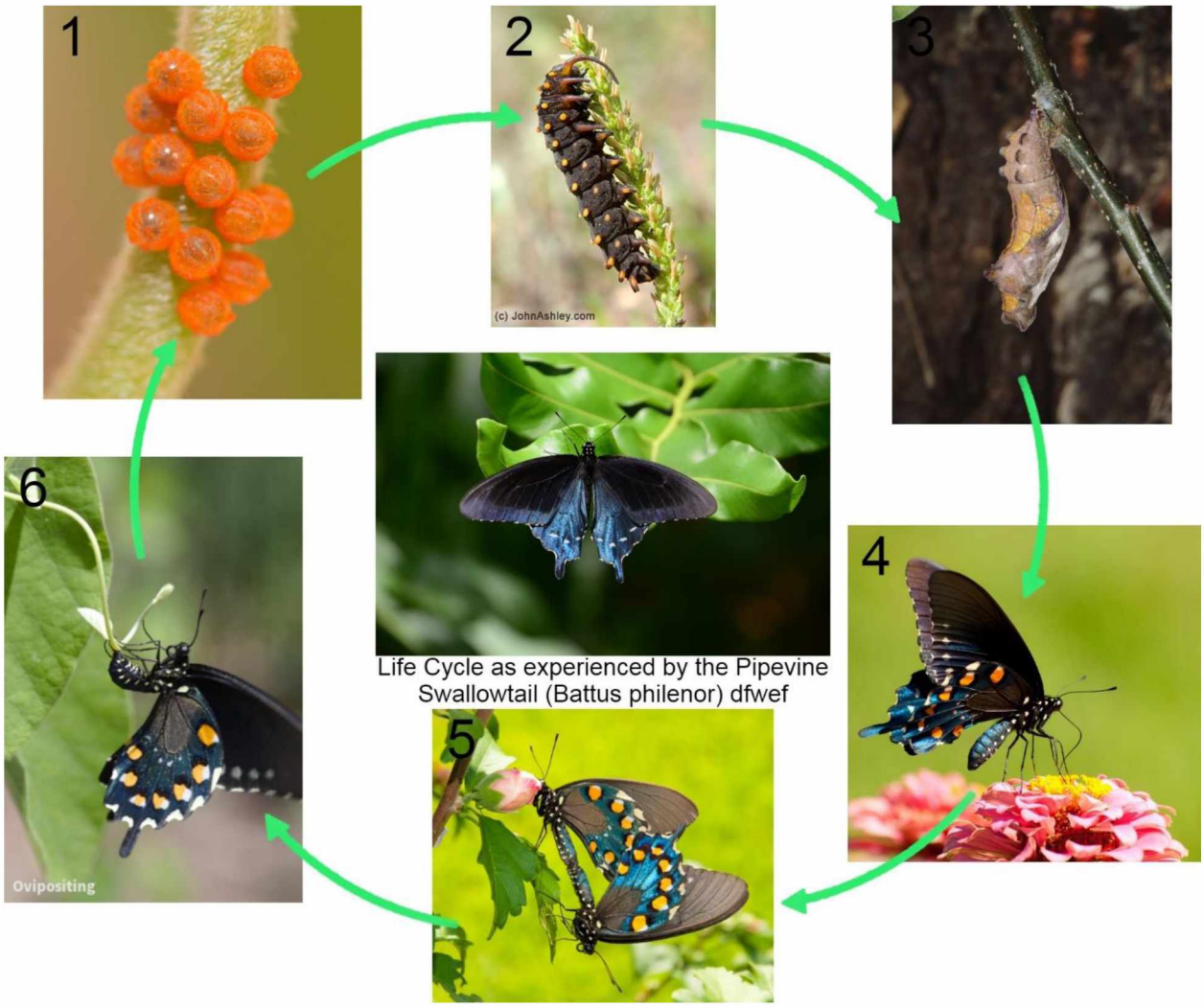


Figure 12. Butterfly life cycle. Photos by: 1. https://www.shutterstock.com/g/okiepony, 2. JohnAshley.com, 3. https://www.shutterstock.com/g/Liz+Weber, 4 & 5.. https://www.shutterstock.com/g/okiepony, 6 Yvi San; Life Cycle of a Pipevine Swallowtail Butterfly, 2016 Yvi San's Article, center. https://www.shutterstock.com/g/William+C.

BUTTERFLY LIFE CYCLE

- The Egg: The butterflies life cycle starts off as an egg which is placed usually on the leaves of plants. Many species of butterfly require certain types of plants for laying their eggs, which will be the first thing, when hatching the little caterpillars will eat.
- The Larval stage (caterpillar): once hatching, caterpillars begin feeding on the leaf which they were born onto. In most cases the majority of the butterfly's life cycle will be spent as a caterpillar eating and growing until its next stage of life.
- The Pupa (Chrysalis): At this stage the caterpillar has grown to full capacity and begins the process of forming into a pupa, which looks like an ornate shell encasing the caterpillar. Although it may look as though nothing is happening there is a metamorphosis happening inside of the chrysalis. Tissues, organs, and limbs of the caterpillar are transformed and emerges from the chrysalis as a butterfly.
- The Adult Butterfly: This is the most iconic stage of the butterfly's life cycle. The adult butterfly's priority at this stage is to reproduce. Nectar from flowers is used as energy to fly from place to place to mate and to find proper nesting sites to deposit their eggs.

Mosquito: Known to most as insects that suck blood, mosquitoes also have their own place in the ecosystem. This is true for the female mosquito who feed on blood as a source of protein needed for egg production. On the other hand, male mosquitoes never bite or feed on blood, instead, they forage on the nectar from flowering plants, unintentionally pollinating plants along its journey.

Did you know?

At the larval stage *Toxorhynchites rutilus* also known as the mammoth mosquito are predators and voraciously feed on other mosquito larvae.

APPENDIX C: Survey of Local Beekeepers

Survey Purpose and Methods

I wanted to conduct a survey of the public in general, but that was too expensive and time consuming to carry out. With limited time and funding, I focused on local beekeepers, who are better informed than the average citizen on the issues pertaining to this project. The purpose of the survey was to find out:

- what experiences beekeepers have had while managing their beehives,
- what actions they think should be taken to promote pollinators in Fairbanks, and
- what do they see as the primary threat to local pollinators.

The survey questions initially came from the 2015 Dane County Pollinator Protection Task Force Report "Questions for municipal representatives." That survey had several good questions, but they were aimed at city employees, not beekeepers. I made some changes to that survey based on my review of pollinator plans and my research on pollinators. The survey was reviewed by my committee and by Lisa Hayes, an influential local beekeeper and owner of Happy Creek Farm LLC. The final online survey was posted on Microsoft Forms and consisted of three Likert scale questions, seven open-ended questions, and two multiple choice or multiple answer questions. I asked ten friends and family members to take the survey to be sure the questions were clear to people who were new to it.

I posted a request on the Interior Alaska Beekeeping and the Northern Alaska Beekeepers Facebook groups explaining that I was a graduate student working on a pollinator plan for Fairbanks and asking local beekeepers to email me if they were interested in participating. Thirty people volunteered to take the survey. Unfortunately, I cannot report the percentage of local beekeepers represented by this sample because we do not know the total population of beekeepers in the Fairbanks area. In addition, not all beekeepers belong to these Facebook groups and both groups are open to people who are not beekeepers.

The 30 beekeepers who took the survey had three primary concerns: limiting the use of pesticides, educating the public, and protecting bee habitats. The most agreement among the respondents was on pesticides. Ninety-three percent of respondents deemed pesticides the most harmful factor affecting honeybees, hives and honey production. Survey respondents had many ideas for educating the public on the benefits of pollinators in Fairbanks, including how pesticides affect them and ways to control unwanted weeds and insects without pesticides. They also had a strong desire to eliminate spraying for mosquitos and weeds, with all participants indicating their willingness to lobby for government restrictions on spraying. They also desired a list of native and non-native plants that are beneficial for pollinators, but not invasive. I tried to address all their concerns in this preliminary pollinator plan.

Results

This section presents a summary of the answers to each question on the survey. If you would like to see the complete data set, my advisor, Dr. Susan Todd will have an archived copy in case anyone is interested. All answers were anonymous, so no identifying information is included in the data.

Summary of Question 1 & 2. What are the primary threats to honeybees in this area?

The first question was "In your experience what is most harmful to your honeybees, hives, and honey production?" Respondents were able to choose more than one factor as being "most harmful." Pesticides received a weighted average rank of 4.9 out of 5, with 93% of respondents indicating that pesticides were the most harmful. Herbicides received a weighted average rank of 4.2 out of 5, with 63% indicating it was most harmful.

Summary of Question 1. In your experience what is most harmful to your honeybees, hives, and honey production? Rank the following from 1 (least harmful) to 5 (most harmful).

Harmful Factor	Weighted Average Rank	Number and % who chose the factor as "most harmful."
Pesticides	4.9	28 (93%)
Herbicides	4.2	19 (63%)
Extreme weather events	3.2	4 (13%)
Climate change	2.7	1 (3%)
Habitat fragmentation	2.5	2 (6.7%)
Mowing practices	2.0	0
Traffic	1.9	1 (3%)

Question 2 was an open-ended question where I asked if there were additional threats not mentioned in question one. Six of the 17 responses to this question mentioned vandalism to their hives, while 4 of the 17 mentioned pests and pathogens affecting colony health. Respondents also expressed concern about bees shipped from California which sometimes include mites, and concern about mosquito spraying.

Summary of Question 3 & 4. How to reduce harm from pesticides.

Question 3 asked, "What could be done to reduce potential harm from chemical control of mosquitoes and other pests on other lands in the Fairbanks area? There were three desirable factors that survey takers could rank from 1 (least desirable) to 5 (most desirable). The choice **"**Lobby to get legislative action to stop the spraying of pesticides that harm non-targeted pollinators" received a weighted average rank of 4.8 out of 5, with 87% of respondents choosing that as most desirable. "Community education on the dangers of pesticides" had a weighted average rank of 4.7, with 73% of respondents rating it most desirable. Lastly, "Better communication between beekeepers and companies like Mosquito Authority" had a lower weighted average rank of 3.9 and only about half of the respondents felt this was most desirable. I was surprised to see that communication between beekeepers and applicators was relatively low ranking, but that was explained in question 4.

Question 3. "What could be done to reduce potential harm from chemical control of mosquitoes and other pests on other lands in the Fairbanks area? Respondents could choose more than one factor as most desirable.

Harmful Factor	Weighted Average Rank	Number and % who chose the factor as "most desirable."
Lobbying for action against pesticides	4.8	26 (87%)
Community education on dangers of pesticides	4.7	22 (73%)
Better communication between beekeepers & companies like Mosquito Authority	3.9	14 (47%)

Question 4 was an optional open-ended question asking for other ideas for reducing the harm from chemical control of pests in the Fairbanks area. Twenty beekeepers answered the question and 11 of them wanted pesticides banned in the Fairbanks North Star Borough. Seven of them mentioned that education on the proper use of pesticides would help, and three people suggested more use of natural alternatives to pesticides. One mentioned that if sprayers followed the rules for pesticide application, like spraying at night and notifying neighbors, there wouldn't be much of a problem. One person thought that better communication with sprayers would not work because they will "never" follow the rules, so the only solution is to ban spraying.

Summary of Question 5 & 6. How to promote pollinators.

Question 5 asked "The following methods have been used in other cities to promote pollinators. Which of these do you think could be helpful in Fairbanks?" There were 6 methods listed for promoting pollinators that have been used by other pollinator protection plans, all of which related to planting more pollinator-friendly plants. These options had weighted averages from 3.4 to 3.9 and people were split on which of the options were most desirable.

Question 5. "The following methods have been used in other cities to promote pollinators. Which of these do you think could be helpful in Fairbanks?"

Desirable Factor	Weighted Average Rank	Number and % who chose the factor as "**most** desirable."
Plant more flowering plants	3.9	12 (40%)
Create a list of pollinator-friendly plants to use here	3.8	11 (37%)
Encourage local nurseries to supply these plants	3.7	9 (30%)
Create pollinator corridors	3.7	12 (40%)
Encourage individuals & agencies to plant Bee Gardens	3.4	8 (27%)
Hold a tour of Bee Gardens	3.4	8 (27%)

In Question 6, I asked for additional ideas on how to promote honeybees/pollinators in Fairbanks. Eleven of the 19 people who responded mentioned the need for education and outreach via social gatherings, festivals, social media and/or tv and radio broadcasts and commercials. They wanted the public to have more information on the benefits of bees, the joys of beekeeping, that honeybees are not aggressive, the difference between bees and wasps, the health benefits of honey, how to build bee hotels for native bees, and how to encourage other pollinators besides honeybees. Another pointed out that native pollinators and non-native honeybees may be at odds with one another. Two noted that some of the favorite forages for bees are invasive plants like bird vetch, white clover, and mustard plants and we don't want to promote those. One person suggested, "Maybe we could get some kind of "Fairbanks Golden Heart Honey" sticker for beekeepers to make it clear that their honey is produced locally.

Summary of Question 7. Would you be interested in helping with these outreach activities?

Question 7 asked: "Would you be interested in helping with any of the following public outreach and awareness activities?" Survey respondents were able to choose multiple activities they would be interested in. Several were interested in helping create a Pollinator Festival during Alaska Pollinator Week and providing "Bee Friendly Garden" signs for public and private gardens that meet specific criteria. Each of the activities listed had at least a few respondents.

This demonstrates that when planning activities such as these, we should reach out to beekeepers via Facebook to see if they would like to help.

Would you be interested in helping with any of the following public outreach and awareness activities?	Number of Respondents	% of Respondents
Hold a "Pollinator Festival" during Alaska Pollinator Week (June 17-23).	9	20.9
Provide "Bee Friendly Garden" signs for public and private gardens that meet specific criteria.	9	20.9

Develop and install a pollinator exhibit in a public area like Pioneer Park with information about the types of pollinators found locally, pollinator-friendly mowing/planting/pesticide practices, information on pollinator habitats, and websites for further information.	7	16.2
Give talks to schools and organizations.	6	13.9
Hold meetings to educate the public about pollinators and provide information for the participants to improve bee habitat on their land or in their gardens.	5	11.6
Name a "Pollinator Champion" each year who has made a significant contribution to pollinator health in Fairbanks. The name could be unveiled at the pollinator festival.	4	9.3

Summary of Question 8. Have you participated in other outreach and awareness activities?

The majority of the local beekeepers who answered this optional question (11/13) indicated that they already participate in some form of outreach and awareness activities in the community. For example, they teach beginning beekeeping courses, speak at public hearings, post yard signs explaining the dangers of spraying for mosquitos, make presentations at schools, and talk to people about these issues when selling their honey at local markets.

Summary of Question 9. What other outreach activities would you like to see?

Question 9 was: "Are there any other public outreach and awareness activities for pollinators you would like to see in Fairbanks? (an open-ended question)." Five people responded to this and suggested a Local Honey Festival to accompany the Pollinator Festival, where people would get information on bees and the full range of other pollinators and on the dangers of pesticides not just for bees but for other organisms, including people. They suggested having booths at the Home Show, the Tanana Valley Fair, other local events and a booth or exhibit at Pioneer Park. They would like to see more efforts to raise awareness of the benefits of dandelions and other early and late flowering plants.

Summary of Question 10. What types of research would you like to see regarding local pollinators?

Fifteen people answered this question. They would like to see more testing to determine the cause of recent die offs of local bee colonies, they would like to see tests of the chemicals being used to spray mosquitos, and tests of local honey to see if pesticides or herbicides are present—especially honey from hives that failed compared to honey from healthy hives. They would like to see more research on how to build housing for or otherwise benefit native pollinators, like bumblebees and butterflies. They would also like more research on how to overwinter honeybees and research on which plants are most beneficial for pollinators.

Summary of Question 11. Creation of a "Friends of Pollinators" organization.

"Do you think there would be interest in creating a "Friends of Pollinators" organization to help implement the plan and promote local pollinators?" Fifteen (56%) of the respondents indicated that they believe there will be interest in creating a "Friends of Pollinators" organization that would help implement the pollinator protection plan, eleven (41%) thought there "may be interest" and only one thought there would not be interest in this.

Summary of Question 12. Anything else regarding health of local pollinators or about this project?

Question 12 asked, "Is there anything else you would like to share with us regarding the health of local pollinators or about this project?" They would like to see more information on ways for homeowners to create mosquito-free environments without using pesticides. They wanted people to be cautioned that some plants that bees love, like mint and borage, can be invasive.

APPENDIX D: List of Pollinator-Friendly Plants

Dr. Patricia Holloway compiled this list of potential pollinator plants based on 30 years of observation at the Georgeson Botanical Garden at the University of Alaska Fairbanks. This list is based on observation, not on counts of pollen loads. It is a guide to plants that appear to attract known pollinators and might be considered in wildflower meadows, guard rows, gardens and natural areas to promote a diverse population of pollinators. Dr. Holloway is quick to point out that it is not complete and further research is needed (Holloway, n.d.). Additional information was found at https://www.wildflower.org/

For more information on invasive plants please visit https://accs.uaa.alaska.edu/invasive-species/non-native-plant-species-list/

Native Plants

Joe F. Duft

Alder
Alnus sp.

Size: 0 – 115 feet
Bloom Time: There are 5 species of *Alnus* in Alaska with bloom times usually in Mar, Apr, May
Attracts: birds, and mourning cloak butterflies.

Weyand, Phyllis

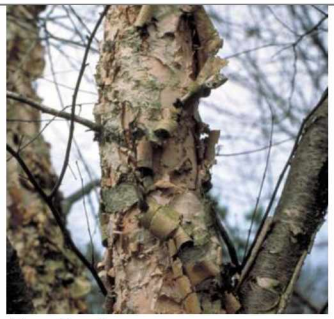
Arnica
Arnica sp.

Size: 0 - 2 feet
Bloom Time: May, Jun, Jul, Aug
Attracts: swallowtail butterflies, painted ladies, honeybees, beetles

Hampton, Nan

Beauverd Spiraea
Spiraea stevenii

Size: 0 - 3 feet
Bloom Time: Jun, Jul, Aug
Attracts: mourning cloak butterflies, syrphid flies



Cox, Paul

Birch
Betula neoalaskana

Size: 0- 50 feet
Bloom Time: May, June, Jul
Attracts: mourning cloak butterflies

Glase, Terry

Bunchberry
Cornus canadensis

Size: Slender 3-6-inch stalks, perrennial, woodland ground cover
Bloom Time: May, June, Jul, Aug, Sept
Attracts: syrphid flies, beetles, moths

Susan Mahr, University of Wisconsin – Madison

Chives
Allium schoenoprasum L. var. sibiricum

Size: 8-20 inches, grows in bunches
Bloom Time: May, Jun, Jul, Aug, Sep
Attracts: syrphid flies, flies, andrenid bees

Cressler, Alan

Cinquifoil
Potentilla fruticosa

Size: 3-4 Feet high and wide
Bloom Time: Jun, Jul, Aug, Sep
Attractss: flies, syrphid flies, honeybees, bumble bees

Weyand, Phyllis

Cottonwood
Populus balsamifera

Size: 20-60 feet
Bloom Time: Apr, May
Attracts: swallowtail butterflies, mourning cloak butterflies, bees (special use for bees)

Weyand, Phyllis

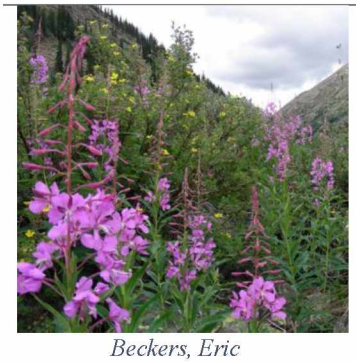
Currants, red and black wild
Ribes triste, Ribes hudsonianum

Size:
Bloom Time: early season
Attracts: honeybees, solitary bees

Smith, R.W.

Dragonhead mint
Dracocephalum parviflorum

Size: 6-32 inches
Bloom Time: Jun, Jul, Aug
Attracts: syrphid flies, andrenid bees



Beckers, Eric

Fireweed
Chamerion angustifolium

Size: 1 – 4 feet
Bloom Time: Jun, Jul, Aug, Sep
Attracts: honeybees, bumble bees
Premier honey plant in AK, premier host of hummingbird moth caterpillars

Bransford, W.D. and Dolphia

Goldenrod
Solidago multiradiata

Size: 0 – 1 foot
Bloom Time: Jul, Aug, Sep
Attracts: bumble bees, honeybees, andrenid bees

Hampton, Nan

Jacob's ladder, tall and beautiful
Polemonium acutiflorum, P. pulcherrimum

Size:
Bloom Time: Jun, Jul
Attracts: andrenid bees, honeybees, swallowtail butterflies

Smith, R.W.

Kinninnick
Arctostaphylos uva-ursi

Size: Height 6-12 inches, spread up to 15 feet
Bloom Time: Mar, Apr, May, Jun
Attracts: bumble bees, wasps, butterflies (larval and adult host)

Hampton, Nan

Labrador tea
Ledum decumbens, L. groenlandicum

Size: 1 – 3 feet
Bloom Time: Jun, Jul, Aug
Attracts: bees, beetles, syrphid flies, butterflies

Lytle, Melody

Lingonberry, lowbush cranberry (Vaccinium vitis-idaea)

Size: 1 – 3 feet
Bloom Time: Jun, Jul
Attracts: bumble bees, syrphid flies, honeybees, wasps

Le Duc, F. Alice

Lupine
Lupinus arcticus, L. nootkatensis

Size: 1 – 3 feet
Bloom Time: Jun, Jul
Attracts: bumble bees, butterflies (food of clouded sulphur butterfly larvae)

Smith, R.W.

Milk vetch
Astragalus spp.

Size:
Bloom Time: May, Jun, Jul, Aug
Attracts: honeybees, butterflies (larval host to Labrador Sulphur, and Hecla Sulphur)

American red raspberry. Image by Mary Ellen (Mel) Harte, Bugwood.org.

Raspberry
Rubus idaeus ssp. strigosus

Size: 1 – 4 feet high and wide often larger growing in clumps
Bloom Time: Jun, Jul
Attracts: bumble bees, honeybees, butterflies

Reveal, James L.

Redosier dogwood
Cornus sericea

Size: 3 – 10 feet
Bloom Time: Mar, Apr, May
Attracts: honeybees, butterflies (larval host to Spring Azure, *Celastrina ladon*)

Glase, Terry

Serviceberry, saskatoon
Amelanchier alnifolia (var. alnifolia, semiintegrifolia)

Size: 4 – 15 feet spread: 6 – 8 feet
Bloom Time: Apr, May, Jun
Attracts: honeybees, bumble bees, butterflies

Shepherd's purse
Capsella bursa-pastoris

Size: 1 – 2 feet
Bloom Time: all season
Attracts: western white butterflies

Bransford, W.D. and Dolphia

Shooting star *Dodecatheon spp.*

Size: 1 – 3 feet
Bloom Time: Jun, Jul
Attracts: honeybees, wasps, bumble bees

Le Duc, F. Alice

Siberian Aster
Aster sibiricus, Euribium

Size: 0 – 1 foot
Bloom Time: Jul, Aug
Attracts: syrphid flies, solitary bees

Cliffe, Harry

Tansy mustard
Descurainia sophioides, Descurainia incana

Size:
Bloom Time: May, Jun, Jul
Attracts: western white butterflies

Weyand, Phyllis

Wild Blueberry,
Vaccinium uliginosum

Size: 8-20 inches
Bloom Time: Jun, Jul
Attracts: bumble bees, wasps, syrphid flies, honeybees, andrenid bees, butterflies (larval host to Heath Sulphur (*Colias chippewa*), Polaris Fritillary (*Boloria polaris*))

Hampton, Nan

Wild iris
Iris setosa

Size: 0 – 2 feet
Bloom Time: May, Jun
Attracts: bumble bees, swallowtail butterfly

Weyand, Phyllis

Wild Potato (Eskimo potato)
Hedysarum alpinum

Size: 1 – 3 feet
Bloom Time: Jun, Jul
Attracts: butterflies, special value to bumble bees

Bransford, W.D. and Dolphia

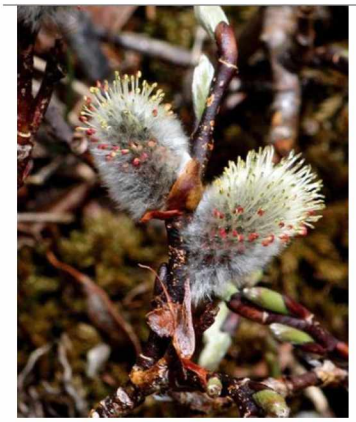
Wild rose
Rosa acicularis

Size: 0 – 4 feet
Bloom Time: Jun, Jul
Attracts: beetles, honeybees, bumble bees, syrphid flies (special value to native bees)

Muller, Thomas L.

Wild sweet pea *Hedysarum mackenzii*

Size: Vine-like 1 – 3 feet
Bloom Time: Jun, July
Attracts: Bumble bees, solitary bees (leafcutter)



Smith, R.W.

Willows, most members of *Salix* genus

Size: 3 – 30 feet
Bloom Time: very early source of pollen for most native and non-native bees
Attracts: Honeybees, mourning cloak butterflies

Lytle, Melody

Yarrow
Achillea millefolium (var. borealis, alpicola, occidentalis, pacifica, nigrescens)

Size: 0 – 3 feet
Bloom Time: all summer
Attracts: Syrphid flies, painted lady butterflies, clouded sulphur butterflies

Samuel Adams

Dwarf Fireweed
Chamerion latifolium

Size: 0 – 3 feet
Bloom Time: Jun, Jul, Aug, Sept
Attracts: Special value to native bees and honeybees.

Figure 13USDA, NRCS, 2000. Cnidium cnidifolium - Jakutsk snowparsley

Jakutsk Snowparsley
Cnidium cnidiifolium

Size: 0 – 3 feet
Bloom Time: Jun, Jul, Aug
Attracts: Beetles, honeybees, bumble bees, syrphid flies, butterflies (larval host to several species of swallowtail)

Weyand, Phyllis

Field Oxytrope
Oxytropis campestris

Size: 0 – 1 foot
Bloom Time: May, Jun, Jul
Attracts: Bumble bees

NON-NATIVE PLANTS

Although the following flowers are non-native, they are incredibly attractive to pollinators and are not believed to be invasive. Species highlighted in yellow indicate plants that have high ability to spread outside cultivation but are not thought to cause native ecosystem impacts in Interior Alaska (AKEPIC, 2019).
To benefit bees, avoid cultivars with double blooms; they often have less pollen.

Raulbot, Wikimedia Commons

Achillea
Achillea millefolium cultivars (var. Arenicola, californica, gigantea, litoralis, megacephala, millefolium, puberula)

Bloom Time:
Mid to late summer bloom period

Attracts:
flies, syrphid flies, butterflies

gardenerspath.com

Bachelor's buttons
Centaurea cyaneus

Bloom Time:
Mid to late summer bloom period

Attracts:
Honeybees

Acabashi, Wikimedia Commons

Black-eyed susan
Rudbeckia hirta

Bloom Time:
Late summer blooms

Attracts:
honeybee

D. J. Bergsma, Wikimedia Commons

Borage
Borago officinalis

Bloom Time:
Mid to late summer blooms.
Caution: may be invasive if allowed to go to seed.

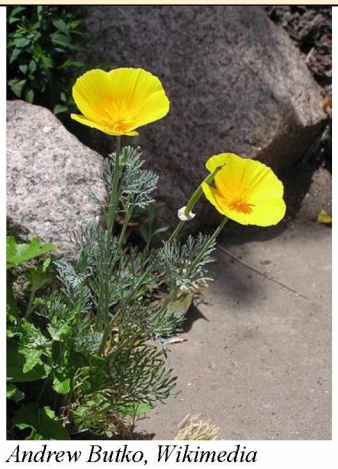
Attracts:
painted lady butterflies

K.G.Kirailla, Wikimedia Commons

Buckwheat
Fagopyrum esculentum

Bloom Time:
Mid-summer

Attracts:
Many types of bees & beneficial insects



Andrew Butko, Wikimedia Commons

California poppy
Eschscholzia californica

Bloom Time:
Great mid-season bloomer

Attracts:
honeybee

Kenpei, Wikimedia Commons

Calendula
Calendula officinalis

Bloom Time:
All season bloomer

Attracts:
Painted lady butterflies

Bogdan, Wikimedia Commons

Canola, rapeseed
Brassica rapa

Bloom Time:
Mid-summer

Attracts:
honeybees

Cesdeva, Wikimedia Commons

Catmint
Nepeta spp.

Bloom Time:
Late spring, summer. There are many species of annual and short-lived perennial mints.
Some may be invasive if allowed to go to seed.

Attracts:
honeybee, syrphid flies

Wilhelm Zimmerling, Wikimedia Commons

Cherries: Selected members of *Prunus* (Russian almond, *P. trilobal*; Ussurian plum, *P. ussuriensis*)

Bloom Time:
Early to mid-summer

Attracts:
honeybees, bumble bees, andrenid bees, wasps, andrenid solitary bees

Kagor, Wikimedia Commons

Chives
Allium schoenoprasum L. var. schoenoprasum

Bloom Time:
Late spring to early summer.
(According to USDA this is native to Alaska)

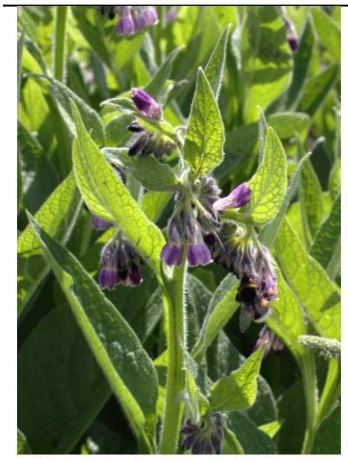
Attracts:
swallowtail butterflies, mourning cloak butterflies, bees (special use for bees)

Fawn Moran, Wikimedia Commons

Columbine
Aquilegia spp.

Bloom Time:
Mid to late season blooms

Attracts:
bumble bees



Wikimedia Commons

Common Comfrey
Symphytum officinale

Bloom Time:
Mid to late summer

Attracts:
painted lady butterflies, honeybees, bumble bees

Krish Dulal, Wikimedia Commons

Coriander
Coriandrum sativum

Bloom Time:
June through August blooming

Attracts:
honeybees, syrphid flies

Wikimedia Commons

Cosmos
Cosmos bipinnatus

Bloom Time:
Mid to late summer
Attracts:
honeybees, bumble bees, syrphid flies

Wikimedia Commons

Crabapples
Malus spp.

Bloom Time:
Early season blooms, pollen and nectar source

Attracts:
honeybees, bumble bees, wasps, syrphid flies

Shahriar Pavel, Wikimedia Commons

Currants, Red and white cultivars
Ribes spp.

Bloom Time:
Early season

Attracts:
honeybees, bumble bees, wasps, syrphid flies

Carolyn Fannon, Wildflower.org

Delphinium, larkspur
Delphinium spp.

Bloom Time:
Late June through Aug blooms

Attracts:
bumble bees, honeybees

Uoaei, Wikimedia Commons

Dianthus many species of annual and biennial pinks

Bloom Time:
Mid to late summer

Attracts:
hawkmoths (aka hummingbird moths)

Herbalistics.com.au

Dragonhead
Dracocephalum moldavicum

Bloom Time:
Mid to late summer

Attracts:
syrphid flies, honeybees

DanielCD, Wikimedia Commons

Gaillardia, blanket flower
Gaillardia aristate

Bloom Time:
Mid to late summer

Attracts:
honeybees, bumble bees, butterflies

Wikimedia Commons

Gooseberry
Ribes grossularia

Bloom Time:
Early summer
Attracts:
honeybees, bumble bees

AfroBrazilian, Wikimedia Commons

Heliotrope
Heliotropium arborescens

Bloom Time:
Mid to late summer, very fragrant

Attracts:
honeybees, syrphid flies

Wilhelm Zimmerling, Wikimedia Commons

Honeyberry
Lonicera caerulea

Bloom Time:
Shrub with edible fruits, very early season bloomer

Attracts:
bumble bees

Thomas Bresson, Wikimedia Commons

Lilac
Syringa spp.

Bloom Time:
June

Attracts:
hawkmoths (hummingbird moths), swallowtail butterfly, bumble bees

Wikimedia Commons

Mint
Mentha spp

Bloom Time:
If allowed to bloom and not fully harvested for herbs. *Caution: some varieties are invasive if allowed to go to seed*

Attracts:
flies, wasps, andrenid bees

Tyler ser Noche, Wikimedia Commons

Mustards spp.

Bloom Time:
These include the plants that bolt in your garden such as Chinese cabbage, broccoli, etc.

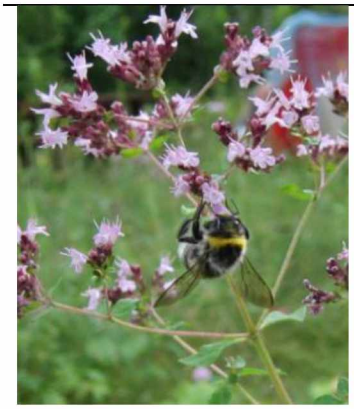
Attracts:
honeybees, bumble bees, syrphid flies

Kenraiz, Wikimedia Commons

Onions, flowering such as Welsh (*Allium fistulosum*) and Altai onions (*Allium altaicum*)

Bloom Time:
Mid-summer blooms covered with insects

Attracts:
syrphid flies, honeybees



Secuki, Wikimedia Commons

Oregano
Oreganum spp.

Bloom Time:
Herb enthusiasts may not want the blooms, but they are a favorite of bumble bees

Attracts:
bumble bees

Faxstaff, Wikimedia Commons

Phacelia
Phacelia tanacetifolia

Bloom Time:
Spring to summer. Often included in non-native wildflower mixes

Attracts:
Bumble bees, honeybees, andrenid bees

Martin Kozak, Wikimedia Commons

Raspberry (cultivated)
Rubus idaeus L. ssp. idaeus

Bloom Time:
June, July.
(Rubus idaeus var. strigosa is native to Alaska)

Attracts:
bumble bees, honeybees

Epibase, Wikimedia Commons

Rosemary
Rosmarinus officinalis

Bloom Time:
Mid to late summer if at all; if you're an herb person, you often pick off the flowers, but bees love them

Attracts:
honeybees, bumble bees, andrenid bees

Siebrand, Wikimedia Commons

Salvia
Salvia spp.

Bloom Time:
If flowers are deadheaded, they will bloom late summer to fall. Many species of ornamental and edible salvias grow in the Interior of Alaska

Attracts:
honeybees, bumble bees

Matt Lavin, Wikimedia Commons

Serviceberry, saskatoon
Amelanchier alnifolia (var. cusickii, humptulipensis)

Bloom Time:
May-June

Attracts:
honeybees, bumble bees

Bilou, Wikimedia Commons

Siberian squill
Scilla sibirica

Bloom Time:
Very early, frost hardy

Attracts:
honeybees, bumble bees

Wikimedia Commons

Snapdragon
Antirrhinum majus

Bloom Time:
Mid to late summer

Attracts:
honeybees, bumble bees

J. Grandmont, Wikimedia Commons

Sunflowers
Helianthus annuus, H. maximiliana

Bloom Time:
Late summer, early fall

Attracts:
honeybees, bumble bees, sweat, andrenid bees, painted lady butterflies

Hugo, Wikimedia Commons

Sweet Alyssum
Lobularia maritiama

Bloom Time:
Blooms all summer, sweet scent

Attracts:
syrphid flies, sweat bees

M. Manske, Wikimedia Commons

Tatarian honeysuckle
Lonicera tatarica

Bloom Time:
Shrub with early season nectar

Attracts:
bumble bees, honeybees

Wikimedia Commons

Veronica
Veronica spp.

Bloom Time:
Mid to late summer

Attracts:
honeybees, syrphid flies

 *Lifar, Wikimedia Commons*	**Viper's bugloss** *Echium vulgare* **Bloom Time:** Summer to fall. Often in non-native wildflower mixes. **Attracts:** honeybees, syrphid flies	

Ground Covers

Katie DiCristina, Manager of the Georgeson Botanical Garden at the University of Alaska Fairbanks provided the following information on ground covers/weed suppressors based on ease of propagation, adaptability to cultivated gardens, aesthetic quality, and relatively fast spread.

Creeping and Common Junipers (*Juniperus horizontalis* and *J. communis*): These are planted together en masse at the Garden entrance. They are excellent groundcovers and definitely keep the weeds down. They are very easy to start from cuttings. Although an effective ground cover and weed block, they are not as aesthetically pleasing as some of the others.

Dwarf birch (*Betula nana*): These might be a nice option for a tall ground cover if someone is seeking shrubs. I have little experience with it in a garden setting I am not sure how well it adapts to cultivation, although it is prolific in our natural ecosystem in Interior Alaska.

Kenai Carpet (*Rubus arcticus*): The Garden had a robust stand of this until grass took it over. Several plants have migrated outside the initial location and it has survived the grass by moving away rather than outcompeting it. It has a naturalistic (i.e. wild) aesthetic and beautiful, delicious (although difficult to pick) berries. The best propagation method may be division, although I cannot speak from experience.

Kinnikinnick (*Arctostaphylos uva-ursi*): We have several areas of this. It is a great, low, easy spreading groundcover. It bears beautiful red berries later in the season. It propagates easily from cuttings.

Creeping dogwood (*Cornus canadensis*): This is a lovely plant, but slow to get started. Once established it can be an effective ground cover and weed suppressor, although it takes several years of patience and attention to attain good establishment. Propagation by seed requires cold stratification. It also has very specific environmental needs (cool, damp, partial shade, acidic soil).

Other possible ground covers of interest might include:

Lily of the Valley (*Convallaria majalis*): Beautiful, aromatic spring flowers! Spreads fast and dense. Some consider it to have invasive properties, so use with caution. Requires shade.

Pussytoes (*Antennaria dioica*): Very low, delicate-looking groundcover. Slow to spread. probably best for small areas.

Strawberry (*Fragaria* sp.): The Garden has areas where we are using strawberries as ground cover. One area is in the apple orchard. They spread fast, but could easily take over areas, so I recommend with caution. And of course, the fruits are delicious!

I would like to experiment with the following in a cultivated landscape:

Prairie sagewort (*Artemisia frigida*)

Mountain avens (*Dryas integrifolia*)

Filipendula hexapetalum